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Volume 25, No. 8

EDITORIAL

Why Is Building So Backward?

SERIOUS searching of our professional soul is suggested by a study of Deane G. Carter's paper which forms the leading article in this issue. The deterioration of the farm building plant, failure not only to provide new structures in step with other phases of agriculture but even to maintain the old, the seeming low estate of farm building in both high and low places, all are nothing new. It has been a chronic condition at least since World War I. A full cycle from war through depression and back to war has not served to break the stalemate. Perhaps it calls for something more than the pressures of external circumstances.

The facts and figures mentioned by Professor Carter are reflected in the experience of our own American Society of Agricultural Engineers. His startling statement that the state agricultural experiment stations have less than one trained structures worker per state, and that industry's contribution is similarly slim, is an indictment. It is confirmed by the relatively small attendance and participation at farm structures sessions of our annual and fall meetings. They are a brave and competent little band, these farm buildings engineers, but they need reinforcements both human and material.

One of our past-presidents once remarked in our hearing that no industry can rise above the level of its sales department. Probably that puts the finger on what ails farm building. With only slight exception, nobody is selling farm structures as completed, functional units. We give away blueprints and industry sells cement, lumber, and steel. The farmer has to hunt for gravel, nails, and labor, and when it is all done he holds the bag. No wonder he prefers to put his money into tractors and combines, automobiles and pianos. Not only are they really sold, but they have responsibility behind them.

By no means do we propose that our skeleton staff of farm structures engineers digress into direct selling. That is a job for men with different training and temperament. Rather than diverting man power from engineering we should add personnel to speed up research that will find answers to countless unanswered questions. Quite possibly the lack of sales promotion on farm buildings is due to paucity of demonstrable data on which sales and advertising experts could build sales campaigns.

We recall the time, years ago, when John Swenehart dropped a bit of bombshell in a paper before an A.S.A.E. meeting which demonstrated that it took a mighty good cow to pay her rent in the kind of dairy barns our structures engineers were designing. It was a wholesome challenge to our thinking. In his present paper Mr. Carter offers a different challenge not only to engineers, but to sales executives. How many of us, or of them, sense the opportunity lying dormant in the fact that in pork production labor costs three times as much as housing and equipment? In dairying, where the ratio is nearly six to one, a reduction of 17 per cent in labor requirement would justify an increase of 100 per cent in the housing and equipment cost.

Humbly we admit having no sure-fire formula to crystallize all these forces and circumstances into a fast-moving program of farm building. We offer our observation that actual sales promotion is done most effectively by private business, and our belief that engineers in public service can best transmute their studies into actual buildings via commercial channels. We also believe that basic research is best done by engineers and scientists in the state experiment stations and similar public agencies, from which follows our suggestion that private business with a stake in farm building can serve itself and the farm public by underwriting research carried on under public auspices. To encourage and expedite such two-way cooperation is a logical and proper function of the American Society of Agricultural Engineers.

Barns Are Built in the City

IN AN address before the American Statistical Association a New York broker, W. Wendell Reuss, demonstrated that rail freight revenues for years have run parallel to the production of automobiles, at the rate of $1,000 per unit. In principle this is identical with the oft-observed parallelism between farm and urban prosperity, e. g., coincident curves for the price of pork and for the volume of industrial payrolls.

From these relations arises the age-old hen-and-egg argument as to which is cause, which effect. We incline to the belief that they are *both* cause and effect, quantitatively divided in proportion to the percentage of population involved. In early times, when our population was 75 per cent rural, it seems obvious that urban business was definitely dependent on farm prosperity. Now, with population 75 per cent urban, it seems equally logical that farm prosperity is similarly contingent on the state of general business.

With the vast amount of re-equipment, soil rehabilitation, and most especially rebuilding that needs to be done in agriculture it is vital that there be a reasonable and stable farm prosperity. Economically it might be possible to push the program with accumulated war earnings. Psychologically it will require a feeling of current prosperity to release such accumulations. And this, we believe, will hinge on general business which is predominantly urban.

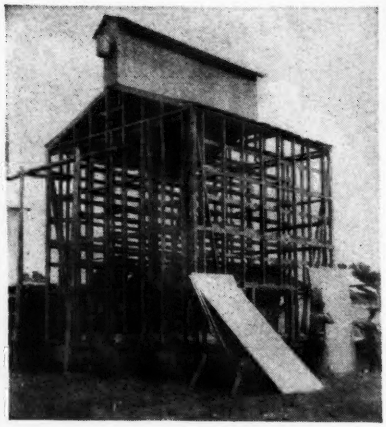
No other single thing will go so far to solve so many of our postwar problems as a large volume of business. It will spur the process of reconversion and minimize the impact of unemployment. It will bear the burden of taxation and strengthen the outlook for national solvency. Our obvious duty is to release the brakes on business, remove the monkey wrenches, and oil its bearings. Both as engineers and as citizens, members of our profession may well exercise their influence to this purpose.

Friends from Afar

AMONG those attending the 37th annual meeting of the American Society of Agricultural Engineers at Milwaukee was Mason Vaugh, agricultural engineer of the Allahabad (India) Agricultural Institute, a member of the Society for more than twenty years but whose attendance is obviously limited to the times of his sabbatical leaves. He told us that among his students has been formed an agricultural engineering society which, it is hoped, will some day embrace all India.

Present also was P. W. Tsou, currently president of the Agricultural Association of China and resident representative in the United States of the Chinese Minister of Agriculture and Forestry. In his briefly informal appearances before the meeting he stated that as yet China has no separate organization of agricultural engineering, but that his nation has much need for the work of our profession, and that he looks toward the time when it will have its organization there. *(Continued on page 314)*

Bright-Leaf Tobacco-Curing Barn of Douglas Fir Plywood



Flue-curing bright leaf tobacco is done in a vertical draft "kiln" with the tobacco leaves closely hung on sticks five or six tiers high. Heat is supplied in the traditional log barns from horizontal radiant flues near the floor, connected to an outside wood burning furnace and exhausting through a vertical outside chimney.

With such processing equipment "killing out" a barn has been an art, requiring judgment and ingenuity to vary the heat and time according to the condition of the product, tightness of construction, air temperature and humidity, and wind velocity.

In recent years agricultural engineers and tobacco specialists have been working on the science of proper processing, with higher quality and greater uniformity as their goal. Air conditioning oil-burning units — "curers" — using blue flame type burners and requiring no smoke stacks were invented. These oil-burning curers give more uniform heat distribution, greater flexibility in heat control and reduced fire hazard. Tighter, better insulated structures and new ideas in ventilation reduce drafts and enable the operator to control curing conditions, with material reductions in heating costs.

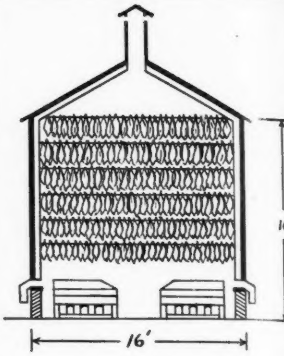
President R. E. Mayo, Florence-Mayo NuWay Company, manufacturers of the oil-burning curer was intrigued by the possibilities of modern plywood construction, and sponsored the construction of an experimental curing barn at his factory in the heart of the bright-leaf tobacco country in North Carolina. The results are best summed up in his report of the project—

"The old log barn is a picturesque feature of our countryside. But the chinking loosens and the resulting drafts disturb the uniformity of the interior air connection currents. A surprising amount of leakage occurs through walls of newer materials, even where the joints appear to be well lapped. This means that the tobacco does not cure evenly, and there is a resulting loss of quality in the product which means an appreciable loss to the farmer.

"Modern oil-burning curers give a very uniform heat control, but show their best results in a tight barn. When the entire barn is cured uniformly it is "killed-out" in a shorter time and with lower fuel consumption.

"For our investigation of plywood barns we used a 16 foot framed barn near our factory. The original side wall material which had given acceptable results was replaced with plywood. Carefully kept data for the previous season had shown a fuel consumption of 90 to 110 gallons of oil per cure. Even though the barn was filled and curing started while the last plywood sheets were being nailed in place only 70 gallons of oil were required to kill out this first barn. Similar fuel savings were shown for each cure through the next two seasons.

"I am sorry to advise that a young tornado found a weak spot in the foundation and sill anchorage last spring and rolled the plywood barn over a few times so we had to salvage what was left. The curing results we obtained with the barn were very satisfactory, and I don't know of any type of material that has greater possibilities than plywood. I plan to build a prefabricated barn when the war is over."



Cross Section of Douglas Fir Bright-Leaf Tobacco Curing Barn

BRIEF SPECIFICATIONS

Erected — July, 1941.

Location — Florence-Mayo NuWay Company factory, Maury, North Carolina.

Size — 16′ x 16′ x 16′

Design — Vertical flue type (traditional design for bright leaf tobacco curing).

Foundation — 4″ brick wall 18″ high.

Framing — 2″ x 6″ studs 16″ o. c.

Walls — ⅜″ EXTERIOR Douglas fir plywood panels placed vertically and glued and nailed to framework with casein glue and galvanized roofing nails 6″ o. c. Horizontal joints beveled to drain to exterior; vertical joints butted.

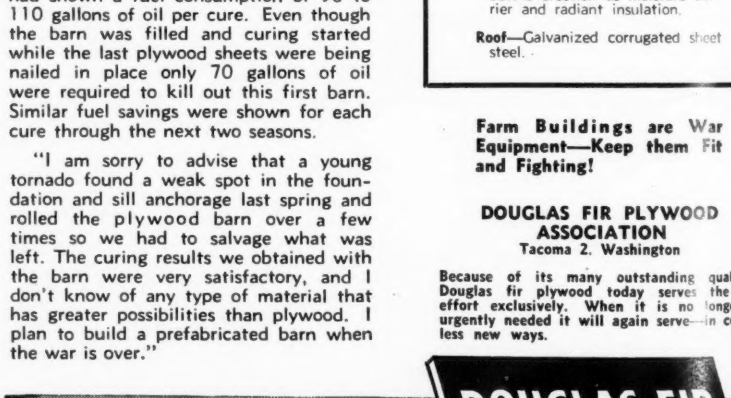
Finish on plywood walls — Two coats linseed oil on exterior; two coats exterior aluminum paint applied to inside of panels before erection as moisture barrier and radiant insulation.

Roof—Galvanized corrugated sheet steel.

Farm Buildings are War Equipment—Keep them Fit and Fighting!

DOUGLAS FIR PLYWOOD ASSOCIATION
Tacoma 2, Washington

Because of its many outstanding qualities, Douglas fir plywood today serves the war effort exclusively. When it is no longer so urgently needed it will again serve—in countless new ways.



SPECIFY DOUGLAS FIR PLYWOOD BY THESE "GRADE-TRADE-MARKS"

AGRICULTURAL ENGINEERING

VOL. 25 AUGUST 1944 No. 8

The Relation of Farm Structures to Agriculture

By Deane G. Carter
FELLOW A.S.A.E.

THE agricultural engineer, whether or not he is a farm structures specialist, is deeply concerned about farm buildings. Farm structures long regarded simply as real estate improvements are now being recognized as functional utilities that have a direct bearing on the whole farm program of efficient production. Important new machines and profitable power applications are at this moment awaiting modifications in structures in order to assure their general acceptance. Changes in agriculture and farming practices virtually compel a broad-scale re-evaluation and redesign of the buildings on the farm.

The empty horse stall is but one symbol of sweeping changes. Grass silage, chopped and baled hay, loft-cured hay, combined grain, increased corn yields, greater soybean production, new crops, and more animals to consume feed and forage, all affect the design and utilization of farm structures.

There is an intimate relationship between the structures on the farm and the agricultural engineering phases of field power and machinery, rural electrification, and the conservation of soil and water resources. The mechanization of crop production has increased the capacity of the worker, permitted more timely operations, and effected almost revolutionary changes in many of the field practices. Electric service has been extended to about two million farms, offering potential advantages in labor reduction, lighting, and the use of appliances and equipment. Soil and water conservation practices have resulted in increased yields, more forage crops, better land management, and modifications in various farming operations to utilize the crops produced.

Each of these phases of power and machinery, electrical development, and soil and water conservation has made tremendous progress within the past 25 years, as indicated by wider acceptance, public support, mechanical improvements, and technical development. They have likewise had an important effect in reducing the cost of food to the consumer. At the same time the profits to the farmer have increased, the heavy labor load has decreased, and the basic soil resources have been conserved. It is apparent to the engineer that the application of engineering principles to the design of farm structures is also a problem of major importance, if the structures are to be adequate and efficient.

In striking contrast to other engineering developments, farm buildings have declined in appraised value, condition, and quality during the past 25 years. The average age has increased, and costs for comparable construction have tended to rise. Census valuation of farm structures was less in 1940 than in 1920, and there was a decline of about 20 per cent in the value during the nineteen thirties. Expenditures for farm buildings since 1920 have not been sufficient to offset the conservatively calculated depreciation and loss in the same period. The estimated expenditure from 1936 to 1941 was 380 million dollars a year, which is about $65.00 per farm per year.

The first buildings erected are still in use on a vast number of farms, and the average age of buildings in many areas is from 40 to 50 years. Conditions were far different when these structures were built, not only with regard to farming methods, but also with regard to building needs, cost of construction, and types of materials available. Few farmsteads have been built as a unit, but rather one structure at a time has been planned, located, and built as the need occurred.

The fact is that there has been no opportune time within the past quarter of a century for making building improvements. Farmers have been faced with immediate problems of low prices, debt reduction, and payment of taxes and interest. Now during the war period restrictions and scarcities limit any program of farm improvement except essential repair and replacement.

In the past, competition has more or less compelled farmers to obtain better seed and better foundation stock and more and better machinery and to otherwise "tool up" the farm for economical production. It is probable that existing labor shortages, production goals, and deterioration in buildings will stimulate a tremendous demand for farm structures, perhaps to the extent that this present period will be looked upon as a turning point in farm structures development.

The scope of opportunity in farm structures development can be visualized by considering briefly the size of the job to be done. Although there is no very sound basis for estimating the dollar volume of postwar farm construction, there are some trends that can be observed, from which some tentative calculations can be made.

It is possible that certain conditions might prevail in the immediate postwar period which would slow down the farm building program to a fraction of the need. Among such possibilities are:

1 Inflated values of real estate, especially if accompanied by an increase in the farm mortgage debt

2 Scarcity of materials and labor or relatively high construction costs and a sharp drop in farm prices

3 Unsettled conditions or uncertainty as to price levels, taxes, public policies, and similar factors

4 The competition of goods and services more aggressively advertised

5 A lack of competent and unbiased advice, planning aids, and information.

On the other hand, there are positive influences that forecast a large volume of farm construction:

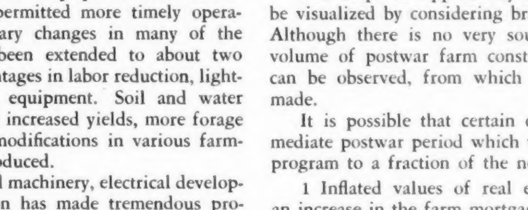
1 Cash reserves available for improvement are at a record high level

2 In many cases present deficiencies in structures should be offset

3 The industrial capacity for producing materials and equipment has been increased

4 Farmers have a better appreciation of the value of adequate structures.

On the basis of need and at 1941 price levels, it is possible that the farm building program might reach a level of two billion dollars a year for the 10 years immediately after the war. The census valuation of 10 billion dollars for all farm buildings is probably less than half the replacement cost; therefore, a 20 billion-dollar estimate of replacement cost would be conservative. The USDA Bureau of Agricultural Economics figures 6 per cent of the replacement cost for repair,



A conventional beef cattle barn and combined crib and granary (Photo: D. G. Carter)

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Milwaukee, Wis., June, 1944.

DEANE G. CARTER is professor of farm structures, University of Illinois.

upkeep, and depreciation; therefore 5 per cent would be unusually conservative. But even at 5 per cent one billion dollars a year would be needed to maintain structures at the present level with no improvement in either quality or equipment.

Although the one billion dollars a year needed for maintenance and replacement is nearly three times the immediate prewar rate of expenditure, it is only about one-half the rate which it would be desirable to maintain for several years in order to incorporate the higher values of insulation, electricity, labor-saving methods, and better structural quality and value. A two-billion-a-year program would do no more than achieve a fair standard over a 10-year period. Many factors besides need will influence the ultimate expenditure, however.

The farm building problem is exceedingly complex. The preparation of plans and specifications is only one step toward solution. Among the complications of design which must be considered are the following:

1 Buildings are relatively permanent and errors in plan or design are difficult and expensive to remedy, and yet conventional farm structures are erected with little professional planning aid and without benefit of adequate research.

2 Typical structures are designed to have a useful life of 20 to 50 years, but still they must serve a constantly changing agriculture.

3 The demand is for designs that are basic in outline and fundamentally correct for the specific use, but a high degree of flexibility and adaptability is also desirable.

4 Designs are prepared for specific situations and materials are developed for exacting uses, but the plans are available to anyone who requests them, and materials are sold to the customer without regard for intended use.

5 Building plans which represented the best recommendations when they were prepared but which are now obsolete are still available, or builders copy outmoded designs from existing structures.

The development of farm building plans and the dissemination of information by both industry and public services tend to complicate the building design problem rather than to simplify it. Many current farm structures plans were originated for specific situations by farmers, production specialists, industrial groups, manufacturers, or distributors and were based upon personal experience, theories, or observations that may or may not have been typical and that might not satisfy the requirements under other conditions. Emphasis on a given material or on some distinctive characteristic of design or form has tended to magnify minor features of some structures.

Failure to render the best service to meet the farm building need and to relate structures to production is due primarily to the fact that neither industry nor the public service agencies have given adequate support to research, promotion, and unbiased technical and educational aid. The majority of states maintain planning services and prepare bulletins, circulars, and blueprint plans. Such plans, however suitable to the respective states, may not be suitable for use in other areas. Also, plans now being distributed are frequently based upon designs that are more than 20 years old.

Only about one agricultural engineer per state is employed on farm building research by the experiment stations in the north central region, and in the United States as a whole there is less than one public service worker per state trained in farm structures. The number of farm structures specialists in the industrial field is small in comparison to the need and to the potential farm market.

Actually the principal responsibility for farm structures has devolved upon farmers, local dealers, and rural builders, most of whom are not trained to select, design, or adapt structures to the specific needs of the farm or the enterprise. At best, the county extension agent and the vocational agriculture teacher are called upon for help. But they have neither the time nor the experience to do the educational job as thoroughly as it should be done.

The farm building needs are therefore (1) a better understanding of the relationship of buildings to agricultural production and (2) more engineering and architectural design, basic research, and educational aid to achieve the objectives of economy, fitness, appearance, and efficiency, and to provide a reasonably adequate service to the farmer.

The relationship of buildings to agriculture involves at least these principal problems: (1) housing for farm operators and their families, (2) cost economy, (3) fundamental requirements, (4) adaptation to specific conditions and circumstances, (5) flexibility, and (6) labor relationships.

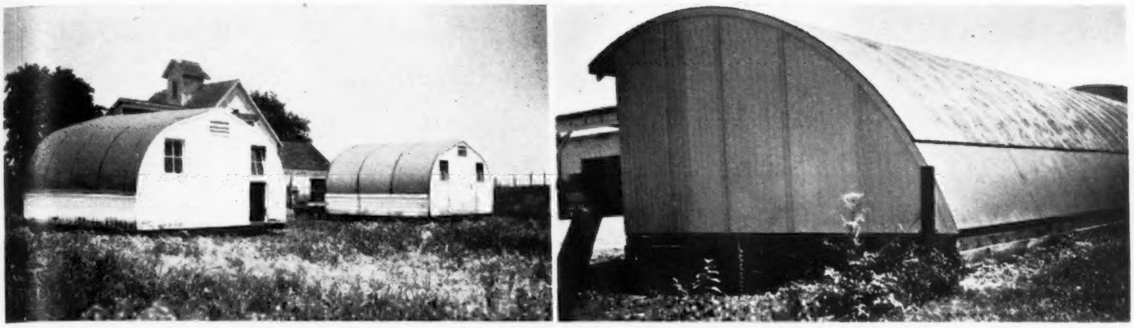
Housing has been largely ignored as a farm structures problem, and yet the farm homes of the nation shelter 25 to 30 million people, or about one-fifth of the whole population. We deplore the low standards of housing in rural areas, frequently without realizing that the cost of housing must be paid from the income of the farm. The rural areas now produce a surplus population which will eventually find its way to the urban centers, and thus rural housing becomes a problem of universal interest.

Cost economy is important at every level, and economic justification is a dominant factor in building design. Actually two aspects of economy must be considered: (1) the limits that the enterprise can carry as the cost for shelter and (2) the optimum expenditure for structural utility and efficient and economical production. In the final application, however, purely economic considerations are not the only criteria. It may often be necessary to accept a less-than-desirable standard because of local conditions. On the other hand, farm owners who have achieved some degree of economic independence may be justified in spending more for the satisfactions they derive from high quality and esthetic value.

The cost of buildings has increased rather consistently since the beginning of the century; the increase has been in wages, transportation, processing costs, and local services, as well as in the improved qualities of material and equipment. This trend toward higher costs is the reverse of trends in many other lines. Cost reduction is a challenge, for the value of better buildings can be extended to more farms if relative costs can be lowered by labor efficiency, the use of power tools, trained service crews, lighter material weights, prefabrication, and simplified construction.

Fundamental requirements involve considerably more than the environmental conditions of temperature, air exchange, relative humidity, and insulation. Clean milk is of such importance that federal, state, and local laws regulate the structures and methods used in production, and in some cases distributors and processors

(Left) A lightweight concrete block poultry house (Photo: Portland Cement Assn.) • (Right) A typical farm elevator built with laminated rafters (Photo: Rilco Laminated Products Co.)



(Left) Prefabricated four-pen hog houses • (Right) A curved-rafter utility or stock shed partly prefabricated (Photos: GHB-Way Homes, Inc.)

have promoted and financed better barns and milk houses. Market grades and use values of hay, corn, small grain, oil seeds, and food crops are seriously affected by the condition of storage, frequently to such extent that storage losses exceed the whole cost of building proper storage structures. An unlimited number of examples could be recited of economic losses resulting from inadequate building facilities, such as rodent damage, insect infestation, fire loss, loss of calves, pigs, and baby chicks, degrading of products, feed waste, and unnecessary labor.

Building types are established by their acceptance in commercial farming areas. The best examples of suitable structures are usually found in areas of intensive production. In the absence of fundamental requirements specified in detail, the better type-of-farming areas yield the best basic building plans from which modifications can be made for other situations. It is not safe to assume, however, that structures for commercial production can be duplicated in non-commercial areas without the frequent necessity for major adaptations.

The adaptation of structures to the conditions and circumstances of the individual farm has been a distinct weakness in relating structures to production. There are no professional planning or architectural services generally available for individual design, and public facilities do not permit the personal services necessary for special planning.

The principal problem is to adapt recommended designs to the specific case, taking into consideration such factors as size, location, type of enterprise, climate, production programs, economic capacity, and all other variables. The suggested solution is the farm planning approach, by which the structural requirements, like other phases of the farm business, are coordinated into the farm plan. By this means, the farm owner, the operator, or any one of a number of agricultural leaders would be competent to analyze the building needs with respect to the farm objective and to determine the requirements of needed structures. Then basic designs, fundamental in outline, could be adapted almost exactly to the farm and locality with some certainty that they would be related to specific needs.

Flexibility in structures is desirable to meet emergency needs for short periods as well as to permit adjustments to changes in rotations, yields, market demands, and management. It is probably unnecessary, however, to jeopardize the optimum design of major buildings for the sake of flexibility. Most of the flexibility needed can be gained by such adaptable devices as trench or wire and paper silos, movable bins, utility storage structures, temporary cribs, straw sheds, and individual hog houses.

Among the many relationships between structures and production, none is more significant than the labor relationships. Not only is the capacity of the individual affected by the facilities available, but also the quality of work, the health and welfare of the worker, and the satisfaction that results from his work. Tremendous reductions have been made in the man time required for crop production, but the labor requirement in and around farm structures has not been reduced appreciably except in amount of time saved in the care of horses. (This is a power and machinery contribution. Illinois farm account records for 1942 show 40 hr of chore time required per horse in return for 260 hr of horse work, whereas 16½ hr chore time was sufficient for the medium tractors that worked 600 hr.)

Altogether, about seven billion man-hours of work a year are required in and around farm buildings. Wallace Ashby estimates this as about one-third of all farm labor requirements. The labor proportion goes much higher on farms where livestock is a major enterprise. In some Illinois areas, work at the farmstead, mostly for the care, feeding, and handling of farm animals, amounts to two-thirds of the total required on the entire farm.

An illustration of the work required in and around buildings compared with field work is found in data taken from the detailed account records of the department of agricultural economics, University of Illinois. These records cover 26 farms in Champaign and Piatt Counties in 1942. The data are averages for the common field crops of corn, soybeans, and oats and the three general livestock production enterprises of hogs, dairy, and poultry on the same group of farms (Table 1).

TABLE 1. COMPARISON OF LABOR REQUIREMENTS* FIELD CROPS AND ANIMAL PRODUCTION: ILLINOIS, 1942

	Crops per acre			Livestock		
Item	Corn	Soybeans	Oats	Hogs (per 100 lb)	Dairy (per animal)	Poultry (flock)
Labor per unit, hours,	7.71	4.02	2.77	2.70	79.86	261.89
Labor proportion of cost, per cent	15.0	8.5	7.0	10.5	20.5	19.5
Machinery and power proportion, per cent	26.5	22.0	17.5			
Building and equipment proportion, per cent				3.5	3.5	7.0

*From 1942 complete cost and farm business analysis on 26 farms in Champaign and Piatt Counties, Illinois, University of Illinois Mimeo. AE2100 (August, 1943).

The man-hour requirement was as follows: corn, 7.71 man-hours per acre; soybeans, 4.02 hr; and oats, 2.77 hr. By way of comparison, it required 2.7 man-hours to produce 100 lb of pork (about the same as for an acre of oats). Each animal in the dairy herd required 79.86 man-hours (the same time for one cow as for 10 acres of corn). The average poultry flock of 123 hens plus chicks required 261.89 hours of labor for the year (equivalent to the labor on 66 acres of soybeans).

Records for a period of several years indicate that the foregoing figures are typical. While crop and livestock data are not exactly comparable, the very striking contrast is worthy of consideration by the engineer and the management specialist if methods are to be found whereby the labor requirement for animal production is to be reduced. Some further data from these records are significant: The labor for animal production was second only to feed as a cost factor and was as much as or more than all other items combined. Labor amounted to 10½ per cent of the cost for hogs, 19½ per cent for poultry, and 20½ per cent for dairying.

The high labor factor was paralleled by costs of 3½, 7, and 3½ per cent, respectively, for building facilities and equipment for the livestock enterprises. In contrast, the very much lower labor percentage on field crops was achieved by an input of around 20 per cent of the whole cost for power and machinery.

The foregoing analysis suggests (1) that the labor cost is the logical item, and perhaps the only one, that can be materially reduced if more economical livestock production is to be attained, and (2) that a higher expenditure to secure more efficient structures and equipment will be justified by reduced labor and lower total costs of production. *(Continued on page 289)*

The A.S.A.E. Tractor Power Take-off and Drawbar Hitch Standardization Program

By W. J. Coultas

MEMBER A.S.A.E.

IN 1938 the Committee on Farm Safety of the Farm Equipment Institute started work on a program to make farm equipment safer to operate. Safety signs for implements and tractors were considered, and an extensive study was made of safety shields over implement power lines.

To carry on this important work an advisory engineering committee of the F.E.I. was organized. This committee is made up of design engineers from various farm equipment companies who voluntarily and gratuitously give no small part of their extra time to the committee's work. In 1939 sample shields were submitted by various members and certain dimensions for a tractor master shield and connecting points for the implement power line shield were established. Adoption of these common dimensions by all manufacturers permitted attaching the power line shield on any make of implement to any make of tractor. This advancement has been recognized as an important factor in reducing accidents resulting from unshielded power lines.

Continued study of the problem soon indicated that to make the program more effective it would be necessary to arrive at some means of reducing the variety of implement shields and power line connections or hookups. This could be accomplished only by arriving at common dimensions for the location of the hitch point on the tractor drawbar and the end of the power take-off shaft.

Accordingly, in 1940 this committee, in cooperation with the American Society of Agricultural Engineers, began a study of power take-off and drawbar hitch locations on farm tractors. As a result of this study, the A.S.A.E. revised and added to its standard dimensions for power take-off and drawbar hitch locations. These dimensions were adopted in 1941 and were then submitted to tractor manufacturers who were most cooperative right from the start. Their sales and service organizations were happy indeed to see such a move that would result in still more effective shielding of the power line, and at the same time help solve the problem of hooking up pull type power-driven implements to tractors, which was reaching a most complex state.

In 1942 tractor manufacturers began changing their design to incorporate these dimensions, and the work has been continued so that now all farm tractors coming off the assembly lines are built to these standard A.S.A.E. dimensions.

At this point a word of praise is in order for the members of the advisory engineering committee who have so unselfishly given their time and effort to this activity in order that simpler and safer farm machinery might become a reality.

To review briefly why some standard was so necessary, let us look back to the time when mechanical power was just replacing horse power. The first mechanical power unit was the steam engine which was used chiefly for belt work and as a mobile source of power for essential machines and for plowing where the terrain permitted. Hitching was simple in those days; power take-offs were undreamed of.

Traction always has been a problem with ground-driven implements. To meet the need for driving a grain binder where ground traction was not sufficient, someone conceived the idea of a power-driven unit, and the power take-off shaft was added to the tractor.

The idea was new, and little thought was given to the location of the power shaft other than to place it most conveniently in the tractor design. Later, new tractor models were introduced, and as a result the power take-off shafts were in some instances over 40 in from the ground and in others as low as 12 in; and they varied from 6 to 32 in ahead of the drawbar hitch point.

It can readily be seen that this wide variation in location created many complex problems, not only in providing suitable power line shields, but also in providing power line connections or hookups as well. Each manufacturer not only had to design and manufacture hundreds of different hookup assemblies, but he had to estimate how many of each assembly would be required to meet the demand. A distribution problem involving the quantities of each assembly to stock at branches and how to regulate dealer stocks to avoid delays in supplying consumer requirements was also created.

Implement warehouses were flooded with a conglomeration of hookup packages, and while storage inventories had to be and were carried, in many cases there was a surplus of some types of hookups, but the combination actually needed was not in stock. Design changes in implements and tractors subsequently added to the variety of connections required.

Dealers especially did not have facilities for handling the wide variety of equipment required to meet all the needs of their customers, and many times it was necessary to telephone or wire for needed parts at the last minute.

The farmer actually suffered the most. Even though manufacturers provided a large variety of connecting parts, in many cases the combination needed was not available at the time, with the result that an improvised hookup had to be made. The village blacksmith was the man of the hour.

Shielding of these improvised hookups was often neglected; in fact, the whole implement connection problem became so complex that even when a farmer did have a safety shield with each implement they became mixed up, and rather than take the time to sort out the correct length shield, the farmer with a crop ready to harvest left them off. Something had to be done.

Many years ago the nation's railroads were faced with a similar dilemma with regard to rolling stock. They solved it by adopting a standard rail gauge and by equipping all locomotives and cars with the same type couplers and the same coupling points. Today railroad cars can travel on the rails of almost any railroad. Why could not a similar program of simplification be inaugurated with respect to farm machinery?

It soon became apparent to implement and tractor manufacturers that adoption of the A.S.A.E. standard power take-off and drawbar hitch dimensions was the only hope of solving these problems. As a result of the efforts put forth by the A.S.A.E. and the advisory engineering committee of the Farm Equipment Institute, all farm tractors are now being built to these standard dimensions, and power-driven, pull type implements coming off the assembly lines are built to hook up to these standard locations.

What are the A.S.A.E. standard specifications? The most important dimensions are as follows:

1. $1\frac{3}{8}$ in or $1\frac{3}{4}$ in spline connection
2. Lateral dimension from hitch point to the rear end of the power take-off shaft, 14 in
3. Vertical dimension from ground line to tractor drawbar from 12 to 15 in
4. Vertical dimension between drawbar and power take-off shaft, from 6 to 15 in.

Establishment of standard dimensions, however, was only a part of the problem. Thousands of tractors are already in the hands of farmers who purchased them before the A.S.A.E. standard was adopted, and some provision had to be made for using new implements, built for use with standardized tractors, with these prestandard tractors. Tractor manufacturers rolled up their sleeves and tackled the job of providing parts to convert these older tractors to the recommended dimensions, and soon these parts will be available for practically all tractors in the field other than some of the earliest models.

To inform implement dealers in regard to ordering numbers of conversion assemblies needed for tractors already in the field and what tractors are already built to the A.S.A.E. standards and therefore require no conversion, a special *(Continued on page 289)*

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W. J. COULTAS is chief engineer, John Deere Harvester Works, Deere & Co.

Soil and Water Conservation in Irrigated Areas

By Frank Kimball

THE successful operation of soil and water conservation programs in irrigated areas requires consideration of a great variety of problems. The engineering phase of this work usually requires the solution of problems of a group or community nature and is ordinarily concerned with works such as the construction, repair, or improvement of irrigation and drainage systems, flood control structures, erosion control works, and other similar jobs. Even though it may be necessary to expend the largest per cent of engineering activity on that part of irrigation work which deals with group problems, it must be recognized that the profits from irrigation farming depend largely on the efficient control of water during its application to crop lands in accordance with the water needs of the crops. Although many farmers have developed their individual water supplies, most of the irrigation enterprises are very definitely of a group nature and each enterprise is more or less peculiar to the lands which it serves. Irrigation, more than any single factor, has made community development possible in the western states.

Irrigation is mainly carried on in the arid and semi-arid sections of the seventeen far western states and also in the states of Louisiana, Arkansas, and Florida. In the western states a great variety of crops are grown, ranging from native hay meadows that use simple irrigation practices to intensive truck garden and orchard farming that requires more complex practices and highly developed water supply and distribution systems. In Louisiana and Arkansas, irrigation water is generally supplied by pumping and is used mostly for the production of rice. In Florida, irrigation is employed in the production of truck gardens and citrus crops.

The area irrigated at present forms but a small part of the extensive acreage of fertile western lands which would be highly productive if sufficient water were available to supplement the scant precipitation and make irrigation possible. Because of these conditions there is little doubt in the mind of any westerner that water is the most valuable natural resource in the arid and semi-arid regions. To give you some idea of the extent and cost of irrigation in the United States the latest census report shows that there are approximately 20½ million acres irrigated on 430,000 farms, and that this acreage is served by 127,533 miles of canals and laterals and 78,528 pumps. The total estimated cost of these irrigation facilities is $1,127,000,000, which represents an average cost per acre of approximately $36.00, whereas the reported average annual cost per acre for maintenance and operation is $2.28.

The sources of irrigation water supplies in the western states are mostly that part of the natural precipitation that occurs as snow or rainfall in the higher mountain sections and is released to natural streams during spring and summer seasons, or the ground-water supplies that collect in underground streams or basins. About 80 per cent of the irrigated land in the western states receives all of its supply from surface streams, and about 10 per cent receives its total supply from ground water. Since there is not enough water to supply all the acres of good irrigable lands in those areas where agriculture is primarily dependent upon irrigation, it has been necessary for the states to adopt very exacting laws governing the appropriation and use of water. Water in the streams of the country is considered to be public property and the individual water user does not obtain title to the water, but he does obtain from the state the right to put a certain amount of it to a beneficial use. Water rights are usually granted to water users by the states according to the dates of their individual applications and proof of beneficial use. In general those who are first, as to time of filing and proof of beneficial use, have first rights to the use of such public waters. For irrigation to be successful the water users must have the greatest possible protection of their water rights; however, each should realize that his individual water right does not entitle him to have delivered at his headgate any more water than he is able to use beneficially.

In the western states a permanent agriculture can only be insured through the proper use of both the land and water resources. The development of a satisfactory water supply without proper use of the irrigation water on the land can result in a condition which can in a relatively short time make some of the irrigated lands useless for cropping purposes, or depreciate their value to a point where their agricultural use is very limited. Every acre of land in an irrigation project that goes out of production because of improper use adds a burden to the remaining productive acres in the project, which must pay for the construction, operation, and maintenance costs to enable the irrigation system to function from year to year.

When irrigation was begun in the western states, farmers had no knowledge of how much water would be required to maintain a growing crop, or how the water should be applied. Little thought was given to economizing in the use of water because there was plenty of it for everyone at that time. Quantities of water far in excess of the needs of the users were diverted from the streams into canals and ditches which were not so constructed as to avoid exceptionally large seepage losses, and it was generally applied to the land in a wasteful manner. Soil erosion and serious drainage problems were created by this kind of water use and some old-timers now tell us that for many years more crops were lost because of excessive use rather than from a shortage of irrigation water.

With the growth of population and the resulting increased demands on available water supplies, the wasteful methods once permissible could no longer be tolerated. It soon became evident that the extension of existing irrigated areas and the development of new projects were very definitely limited by the availability of water supplies, and this factor emphasized the necessity for exercising the proper control over irrigation water. State officials responsible for the administration of water supplies have made considerable progress since those early days in getting water users to repair and maintain their irrigation systems, so that in all the western states there is now less uncertainty as to what constitutes reasonable beneficial use by the appropriators in exercising their water rights. However, there are still thousands of irrigators who need to know more about the water requirements of their crops, more about the capabilities of their soils to produce under irrigation, and what physical adjustments must be made to their farm distribution systems to obtain the most efficient and economic uses of their water supplies. Of the 20,500,000

A contour-planted orchard in Utah. As the trees grow large, additional furrows will be used to irrigate them

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FRANK KIMBALL is head, irrigation section, engineering division, Soil Conservation Service, U. S. Department of Agriculture.

acres of land now irrigated, it is estimated that 11,700,000 acres are in need of supplemental water and irrigation system improvement and that conveyance losses of water in distribution canals averages almost 30 per cent of the total amount turned into these canals. While it would not be economically feasible to provide linings for a major portion of the existing 127,000 miles of canals and laterals, it is believed in many areas that conveyance losses could be reduced by as much as 50 per cent by taking the more practical approach and treating only the badly seeped section first.

Another condition which is the source of trouble for some water users is found in areas where close rural settlement has taken place as a result of irrigation agriculture and where all possible water developments have been made. Crop failures may be expected by the holders of junior water rights in these areas when water shortages occur. In many instances it would be possible to provide greater economic stability for such communities by encouraging farmers to make better uses of existing water supplies so that the savings could be extended to a larger number of water users. When more water is applied to crops than is necessary to bring them to the harvest period just to maintain the *status quo* of a senior water right, or because of inattention to the mechanics of irrigating, serious damage often results to the lands and crops of the owners of both the senior and junior water rights. In the case of the former, it is usually because of erosion, drainage, or alkali problems created, while in the latter case it is because of water shortages which might have been avoided.

Dr. H. H. Bennett has told us that there is as much variety in erosion as there is in landscape, and irrigation problems are also about as varied. We are indeed fortunate that so much valuable research data are available to assist us in solving many of the problems with which we are confronted.

Irrigation research in the Soil Conservation Service is under the direction of W. W. McLaughlin, who has been chief of the division of irrigation since 1926. The division was transferred from the former Bureau of Agricultural Engineering to the Soil Conservation Service in 1939. The history of irrigation research in the Department of Agriculture and the history of the major irrigation developments cover the same period. The publications by the experts in this division of the Department cover all phases of irrigation problems. Their work in irrigation research has quite properly been directed along lines that promote the best uses of water and land, not only with a view to securing good current crop yields, but also to assist in permanently maintaining a high state of productivity on irrigated lands.

Research has been conducted throughout the 17 western states in connection with the many problems having to do with the development, transportation, and use of water in agriculture. The development of the Parshall flume, the assembling of data on water requirements of crops, studies of water laws, irrigation methods, and many other activities have been invaluable to the progress of irrigation agriculture in the West.

One of the most important functions of this division is its leadership in carrying on snow surveys and forecasting water supplies. Many irrigation districts rely upon these forecasts to enable them to regulate their storage facilities in making the maximum use of available water supplies. These surveys have become so useful that there is now a widespread demand for the establishment of additional snow survey courses to provide more complete coverage of the western irrigated lands.

Since the needs for agricultural products at this time are so great, every effort should be made to obtain maximum benefits from our soil and water resources, especially in irrigated areas where crop yields and values under good management are much higher than in the average non-irrigated areas. Wartime needs for crops, such as meat and dairy products, have greatly increased the demands made on irrigated lands, and somehow the farmers have been able to meet these demands in spite of serious shortages of man power and farm equipment replacements. Farmers today, more than at any previous time, are also learning the value of local group organizations to help solve their problems. In helping to bring about these benefits the Soil Conservation Service has taken a prominent part in assisting them to plan and put into operation improved irrigation structures and improved irrigation practices. This work has been accomplished mainly through the medium of soil conservation districts, a type of organization that has proved well adapted to helping farmers solve their group problems.

During the past three years the soil conservation district movement has been strongly endorsed in irrigated areas. In this period new districts were organized to include some 3,000,000 acres of irrigated lands. At the present time there are approximately 255 soil conservation districts in irrigated areas. They include nearly 4,000,000 acres of irrigated lands, one-fifth of the total irrigated acreage in the United States. Although the irrigated lands in these districts occupy only a small percentage of their total area, they are of vital importance to the agricultural stability of the remaining district lands.

Approximately 15 per cent of the total irrigated lands are used for the production of vegetables, fruits, and nuts. These rate as the lands of highest value now in use for agricultural purposes, and generally their irrigation systems have been more carefully planned and constructed than in the remaining irrigated areas. The greatest number of individual pumping installations are found there, and the costs of developing the water supplies for individual farms have been considerably higher than for any other irrigated lands.

Soil conservation districts in these areas are usually small when compared to those in livestock and general farming areas. Also the problems to be solved in obtaining the best land and water use require greater skills on the part of the technicians working in these districts. Many of the problems are of such complex nature that field investigations and engineering surveys extend, in some areas, over a period of several cropping seasons before physical adjustments can be completed.

Engineering surveys for the alleviation of erosion, flood control, drainage and water development problems have occupied the time of most of the technicians working on these lands. More specifically the engineering work on individual farms has been in connection

(Left) A portable V type irrigation flume which has 1-in circular openings spaced the same as the furrows. Flow of water is controlled by small metal slide gates • (Right) This picture shows an 8-in galvanized surface pipe with 1-in internal, flow-control gates which may be used as a head ditch in irrigating steep or uneven ground. When used as an intermediate head ditch, the position of the pipe may be shifted for through cultivation of row crops, since this pipe has the advantage of being portable

with installation of sprinkler irrigation systems, substitution of pipes for open channels, bench terracing, contour planting, farm storage reservoirs, spreading water for underground storage, and drainage.

Many orchards have been square planted on steeply sloping lands and have thereby created difficult problems of erosion control and required the most costly types of water distribution systems to solve these problems. Each individual orchard has its own particular problems and very little can be said that will apply generally to all of them. Because of the high values of orchard crops careful attention must be given to the water requirements of the trees to prevent their suffering from a shortage of moisture or being drowned out with an oversupply. Progress has been made in controlling erosion in some orchard areas through the use of cover crops, while in other areas the land-owners prefer the use of broad, shallow furrows and clean cultivation to attain the same results.

Where vegetable crops are grown extensively, the lands are usually of the highest quality and the water supply systems are maintained in good operating condition, consequently there have not been many requests for technical assistance in such areas. Careful land leveling, maintenance of a high state of soil fertility, control of weeds, and well-regulated water applications are some of the important factors influencing the success of this type of farming.

Increases in population due to war construction operations in several of the western states has improved the market outlet for truck crops to a small extent. Until the beginning of this war period, however, truck crop production met with ever-increasing competition from other sections of the country. This has made the growing of fruits and vegetables a highly speculative undertaking with profits dependent upon high-quality products produced with low labor costs and timed to reach the markets to get best prices.

There is an inseparable relationship between the irrigated lands and the livestock economy of the western states. It has been estimated that about one-half of all supplemental feed for livestock in these states is produced on the irrigated lands. Alfalfa which is one of the principal feed crops for livestock is grown on approximately 30 per cent of the total irrigated acreage and, if we add irrigated pastures and other forage crops grown under irrigation, the irrigated land in forage would probably reach 50 per cent.

The opportunities for accomplishing soil and water conservation work in these areas are perhaps more extensive than in any of the remaining irrigated sections. It is in this hay and supplemental feed area that most of the wild-flooding type of irrigation is practiced and irrigation systems have been less carefully constructed than in areas where higher priced specialty crops are grown.

MANY SMALL DIVERSIONS AFFORD GOOD OPPORTUNITIES

There are many small diversions serving isolated sections of mountain valleys and meadow lands which afford good opportunities for yielding increased feed supplies. Such increased crop production depends mostly on the state of repair in which the irrigation systems are maintained and the care which is exercised in the application of irrigation water. Stands of native grasses have deteriorated in far too many of these areas because of excessive water applications or because of inattention to the irrigation systems in years when range forage was most abundant. Livestock operators realize the importance of having these supplemental feed reserves, but they are too often found riding the range when the less congenial work of irrigating has to be done. The lack of readily available labor in these areas has also greatly aggravated the kinds of problems which could be greatly alleviated through better water use.

There are many other areas in the livestock country where closer rural settlement has occurred and where most irrigation problems are of a group or community nature. The types of group problems which Soil Conservation Service technicians are usually requested to assist in solving include those dealing with organizational matters, the diversion and storage of water, and delivery of water to farm laterals. Problems of drainage, flood control, and waste water disposal are also important in many areas.

The type of assistance made available to the water users in the Purgatoire Soil Conservation District in Colorado furnishes a good example of how locally organized groups are working together to solve their problems. This district in southwestern Colorado includes a total area of 438,000 acres of which approximately 37,336 acres are irrigated, 45,000 acres are dry-farmed, and the rest are used mostly for grazing by livestock. The available forage on these range lands is such that stockmen usually figure a safe carrying capacity for grazing by cattle at the rate of approximately 50 acres per cow on a year-long basis. Supplemental feed requirements are supplied from the dry-land farms, irrigated farms, shipped in, or the stock is moved to other areas in seasons of shortages. The annual production of irrigated alfalfa for supplemental feed for livestock in the Purgatoire district averages about 30,000 tons per year, which emphasizes the importance of irrigation in the livestock economy of the area.

Floods in the Purgatoire River in 1942 either completely destroyed or rendered inoperative several diversion dams and other irrigation structures in this district. As a result of these damages, 15,615 acres of highly productive irrigated lands were left without diversion works to supply water to the main delivery canals. Because of lack of storage reservoirs in this area practically all irrigation water is supplied from the river through direct-flow ditches, and it is readily seen how important it is to water users that their diversion structures be in condition to divert water at all times since the flow of the river is at the lower stages during most of the year.

The farmers' problems became more acute when this area was visited by a severe drought and the rainfall during the growing season was not sufficient even for normal growth of dry-land crops.

The Soil Conservation Service and the Forest Service, working with the district board of supervisors of the Purgatoire district, furnished technical assistance and some major construction equipment in making temporary repairs to the damaged diversion structures of 6 irrigation districts in this area immediately following the flood. This work directly benefited 10,000 acres of the irrigated lands during the 1942 crop season and prevented serious damage to supplemental feed supplies.

SCS TECHNICIANS ASSIST IN DAM CONSTRUCTION

During the non-irrigating season in the fall of 1942 and spring of 1943, the Soil Conservation Service technicians completed surveys and plans for and assisted the supervisors in the construction of the two major diversion dams which had been destroyed, the repair of main delivery canals, and the construction of stream-bank protection adjacent to the diversion structures. One of these dams, which was originally constructed with steel sheet piling and concrete, was replaced with a log and rock crib structure, using all local materials and farmer labor. The other dam, an ogee type of concrete structure resting on wood piling foundation, was restored to its original condition. The improved structures were all put into operation for the 1943 crop season and each functioned effectively.

The farmers have shown a greatly increased interest in their soil conservation district since they completed this work and have been making very effective use of this local organization in establishing conservation practices on their individual farms.

During the past year the Soil Conservation Service has made technical assistance available to more than 200 irrigation enterprises in planning for the solution of community type problems. Most of this work has been with small groups of farmers and has largely been concerned with problems of improving water supply and distribution systems. In many cases the preliminary investigations, surveys, and planning for this work must be carried on over periods extending for more than a year's time, and most of the improvement work must be done in the non-irrigation seasons, usually in the fall and spring months.

Construction operations have been severely restricted in all states because of shortages of labor and equipment and many urgently needed repair and improvement jobs have had to be postponed, but there has been no letup on the demands made on farmers to produce more food. Under these conditions irrigators have learned and demonstrated the value of conservation methods in securing the increased production needed. Irrigators have proved this on many farms by exercising more careful controls in applying water to crops, leveling uneven lands, using fertilizers and soil-building crop rotations, and practicing contour cultivation.

Although the solution of group problems is of primary interest to the irrigation farmer, because this usually means satisfactory delivery of water to his farm headgate, he also has a full-time job of soil and water management on his farm in carrying out his routine farming operations.

Farm conservation plans are prepared by the technicians and individual farmers working together to provide the most efficient water distribution systems possible, giving due consideration to all local factors of influence. These plans also include as much specific

information and data as it is possible to give to the farmers for their guidance in making the best use of their water supplies. In order to make specific recommendations, it is necessary to know the amount of water available and its method of delivery to each farm headgate. Arrangement of fields and land preparation can then be made to fit into the cropping system to be used. This will entail studies of topographic and soils influences, the water requirements of the crops and their estimated frequencies of irrigation.

The war-depleted ranks of Soil Conservation Service technicians last year were also able to give some planning assistance to the owners and operators of more than 250,000 acres of irrigated lands. In providing this assistance many different kinds of action were necessary to serve irrigation interests because of the wide differences in climate, soils, water supply, and types of crops grown.

During the year emphasis was placed on efficient and beneficial uses of water in order that available supplies would help produce optimum crop yields and irrigate the maximum acreage. Farmers' interest was especially directed toward such factors as time, rate and amount of water applications, water-holding capacity of soils, and control of water on the farms from head ditches to waste ditches.

Some leveling, tractor, and dragline types of equipment were made available to irrigation enterprises by soil conservation districts. This generally resulted in considerable advancement of the food production program by the increase of crop yields and at the same time reducing farm labor requirements.

It has been necessary in making structural improvements to use non-critical war materials so far as practicable. Many diversion dams have been constructed of native logs and rock. Emphasis has also been given to cleaning and realigning of canals, repair of seeped sections of canals, and the installation of water-measuring and control devices. Many individual farm irrigation systems were revised to make better use of water supplies, to reduce erosion hazards caused by excessive irrigation grades and improper application of irrigation water, and to facilitate the use of the land in accordance with its capabilities.

PREPARATION OF PLANS OCCUPY ENGINEERS' TIME

Preparation of farm conservation plans occupy most of the engineers' time in soil conservation districts, mainly in connection with planning for land preparation and improvement of farm distribution systems. Generally the farmer is most concerned with the ability of his distribution system to supply the needed amounts of water to his crops in the shortest length of time. The farm plan should indicate the best irrigation methods to enable him to achieve this objective, but at the same time secure uniform application of water to his crops without soil erosion or waste of water. The skill with which the farmer operates his irrigation system in applying water to crops is usually one of the most important factors influencing his crop yields. No matter how expert the irrigator may be, he cannot efficiently irrigate a field that is poorly prepared or leveled and therefore prevents an even distribution of water to the crops. Uneven water distribution makes an uneven growth of crops. Where rolling topography and steep slopes are irrigated, additional structures are usually required in order to control the water properly. Far too many farmers irrigate lands which need leveling and improvement of irrigation systems, and thereby waste water, labor, and the opportunity for larger crop yields. The Soil Conservation Service is expending considerable effort to show these farmers how to make the most efficient use of their water supplies.

The farm distribution system includes the ditches, pipes, flumes, and appurtenant structures that are necessary to convey irrigation water from its point of delivery on the farms to the various farm fields. A contour map of the farm is usually necessary in determining the best locations of laterals, field ditches, field boundaries, direction of border strips, etc. Farm laterals must be located so that water can be delivered through a system of sublaterals and field ditches to the highest elevations on the land to be irrigated, and each lateral should serve the greatest possible area. Laterals and ditches must be designed to provide the most economical cross section and non-erosive gradients consistent with the heads of water used, and also for ease of maintenance. When laterals are in porous soils, some lining, or use of pipes or flumes, may be required to prevent excessive seepage losses. On gently sloping lands it is often desirable to locate laterals along field divisions and property lines to facilitate their operation and maintenance. The installation of meter gates, wiers, Parshall flumes, or other types of measuring devices should be recommended for each farm distribution system to eliminate guessing as to the amount of water being used.

Head ditches should be located at the higher ends of the fields, with a sufficient number of turnout structures to provide for adequate control and distribution of water to the fields. In the case of long fields it is often desirable to use additional head ditches so that the length of run of water over the land will facilitate a fairly uniform penetration. These additional ditches may also be used to collect any excess water from the upper parts of the fields and redistribute it to the lower parts.

Field ditches which require annual replacement should be located so that a minimum number of simple water-control structures, such as canvas dams, portable wiers, pipes, etc., will suffice when applying water to crops. Field ditches for flood irrigation of alfalfa and grain, where rolling topographic conditions exist, should be laid out on near contour grades and the spacing between ditches sufficiently limited to provide for uniform distribution and generally short runs. Furrow irrigation under similar conditions should also follow near contour grades with provisions for effective control over the quantity of water entering each furrow through the use of lath boxes, spiles, tubing, or similar devices serving as outlets in the supply ditches.

KNOWLEDGE OF SOIL PROFILE CHARACTERISTICS IMPORTANT

A knowledge of the profile characteristics of the soils in the various farm fields, including factors such as texture, depth, and water-holding capacities, will enable irrigators to make the most efficient uses of their water supplies. Trial irrigations to determine the depth of water penetration into the soil and the most desirable lengths of runs provide a very practical approach in selecting the methods of application and amounts of water to be used. The experience gained in the actual irrigation of any individual farm considering the combined effects of all local factors of influence, such as cost and availability of water, care with which the land has been prepared, permeability of the soils, number of cultivations, crop diversifications, and climate will enable the irrigator to become proficient in estimating the gross water requirement of his farm and to regulate water use with a minimum amount of labor, thereby increasing the degree of control which he can exercise over his own economic status. It is the duty of every irrigator to make liberal use of a moisture probe and a shovel to determine the uniformity, distribution, and penetration of water in each field he irrigates until he becomes thoroughly acquainted with its physical characteristics.

The cropping system on each farm should be planned to make the most effective use of available water supplies, using a margin of safety that will allow for ample water throughout the irrigating period for the various crops grown. When it is known that water will not be available in the desired quantities throughout the crop season, full advantage should be taken of the capacity of the soil for water storage. This may require a few additional irrigations before the soil reservoir has had its water content materially depleted in order to make full use of soil storage capacity while the water is still available in the supply system.

It should be recognized, however, that the development of efficient irrigation methods depends on consideration of the factors affecting each individual farm. The practice of using the soil for storage purposes because of shortage of water later in the season is one that requires very careful manipulation in order to avoid leaching and water logging. It is generally considered better practice to change the farm management plans to include crops which are better adapted to the climatic conditions and available water supplies.

In the early part of the growing season water requirements of crops are not large because of immature plant and root development and low transpiration and evaporation. It is generally necessary to increase the amount of water with successive applications in order to promote good root penetration and plant growth. Where water is obtained from limited storage facilities, it is very important that adequate reserve supplies are retained for the heavier late season demands as the crops approach maturity. The cultivation of crops in the intervals between irrigations will assist in controlling weed growth and in conserving soil moisture for crop use.

The maintenance of soil fertility of land under irrigation is quite important because of the need for additional plant food to produce high crop yields, and in some cases because of unavoidable leaching of plant food by irrigation water.

During the past three years production goals have been set at very high levels and the resulting intensive use of many agricultural lands has drawn very heavily on soil fertility. Continued high production levels are absolutely necessary, and this means that there must be a corresponding increase in the use of manures and fertilizers to keep the soil bank account in balance.

In conclusion, each of us who are engaged in conservation work in irrigated areas should always bear in mind that the degree of success obtained in influencing irrigators to adopt sound water use and conservation practices on their farms depends first on the availability of water at their farm headgates. Next in importance are the adequacy, state of repair, and efficiency of their farm distribution systems. When these physical factors are under control, the irrigator must then perfect his working knowledge of the soil and water relationships and of the plant and water relationships on his farm in order to make the best use of his irrigation system. The necessary modifications in his operations due to the combined effect of all local factors of influence will be made as experience is gained.

Soil and water conservation in irrigated areas is paying good dividends, and the farmers who have adopted policies of good water use and good land use have generally made an outstanding contribution to the nation in helping to meet the heavy demands for wartime food production.

Farm Structures

(Continued from page 283)

Present conditions and the limitations on building present an opportunity to the engineer to find a solution for the farm building problem which will contribute more fully to efficient, economical production. In facing the task ahead, however, we must not overlook the contribution of the pioneer researchers and educators in the structures field. In spite of the status of farm structures services, which a leading business magazine characterizes as "utterly ridiculous," much has been accomplished that is of real value.

No one questions the value of Wooley's economic study of farm buildings in Missouri. Davidson and his associates at Iowa deserve much credit for the plans and publication initiated many years ago. Kelley's ventilation, Patty's rammed earth, Barre's grain storage, and Smith's poultry housing are but a few of the studies that add to the total of our understanding. The Midwest and regional plan services, the U. S. Department of Agriculture coordinated reports on "Requirements" of buildings, the regional grain storage studies, and the Wisconsin dairy barn project are setting the pattern for farm structures progress. Credit is due likewise to the men in the industrial field who have contributed and are still contributing to better buildings.

Nevertheless the farm physical plant today stands in need of nearly complete rehabilitation and redesign to incorporate structural durability, improved efficiency, better appearance, and fundamental production requirements, and to contribute to a higher standard of farm life. No single set of specifications will meet all needs, and no one program can be devised to solve all problems.

Although the service buildings (excluding dwellings) represent only about 18 per cent of the whole farm investment and between three and nine per cent of the cost of animal production and crop handling, they bear an intimate relationship to agricultural production and to the other engineering aspects of agriculture. Buildings affect the quality and condition of stored products, the sanitary control and market condition of food items, the prevention of disease among farm animals, the utilization of feed and value of manure, the conservation of breeding stock and young animals, the appearance and esthetic value of the farm, and the amount and quality of labor required for production.

Prompt action is required if engineering design is to contribute fully to the development of farm structures in the postwar period, and there is increasing evidence that such action will be forthcoming. The state colleges of agriculture have recently prepared reports on a program for rural housing and farm building after the war. In these reports, there is a nearly unanimous agreement concerning the need for extensive research and educational aid for the development and improvement of farm buildings. County farm and home extension agents, vo-ag teachers, materials dealers, and rural builders are in position to render outstanding assistance in farm structures improvements, and they are demanding planning aids and technical information as a basis for service to farm families. The industries have indicated their interest by aggressive support of proposals for public aid to education and research and by increased contributions to cooperative investigations. Conferences of research workers in the north central region have been held recently to plan a unified program of investigation on problems of regional significance. Other state and federal government agencies and commercial interests are developing postwar plans that affect rural building.

There is ample evidence to indicate that farm structures development in the immediate postwar period may be the most important program in agriculture. The interests of all divisions of agricultural engineering are affected by the engineering design that will be utilized in the solution of the problem of the improvement of farm structures, the arrangement of the farmstead and the utilization of equipment and labor-saving methods for efficient operation.

A.S.A.E. Tractor Standards Program

(Continued from page 284)

committee was appointed to consolidate under one cover information pertaining to all farm tractors. This was published by the A.S.A.E. as Bulletin No. 44, and distribution of it is being made to all farm equipment dealers and service men.

Implement manufacturers have also done their share by providing suitable connections for new implements to be used with standardized tractors and conversion packages or parts to permit using old implements already in the hands of the farmer with new standard tractors. Bulletins pertaining to implement conversion have been compiled and will be or have been distributed by the individual implement manufacturers.

In view of the A.S.A.E. standardization program, dealers and farmers will be confronted with four possible combinations, as follows:

1 *New Implements with New Tractors.* Obtain new standard hookup or implement connection packages.

2 *Old Implements with Old Tractors.* Use old hookups or implement connecting packages.

3 *New Implements with Old Tractors.* Obtain tractor conversion assembly as listed in A.S.A.E. Bulletin No. 44 from dealers handling that make of tractor.

4 *Old Implements with New Tractors.* Obtain implement conversion packages from dealer handling that make of implement in accordance with information supplied to him.

Service organizations of the tractor and implement manufacturers are conducting special campaigns to acquaint thoroughly their branch house, service engineer and dealer organizations with the entire program. With information thus far available we are confident the entire program will be understood and little difficulty experienced during the conversion period, and soon farmers as well as dealers will recognize this to be a workable and worth-while program.

The conversion program as a whole covers the majority of problems that will arise for farmers and dealers, but there will be exceptions which will require special treatment. The next few years will present some difficulties in working out the few special cases. United effort and complete cooperation between competitive dealers, branches and factories will hasten the day when the present hookup problem will no longer exist. Some advantages readily apparent will be as follows:

Increased Safety. Better and more effective shielding of the power line.

Convenience. Connections that will fit, eliminating homemade hookups. Most pulled type, power-driven implements can be used with any make or model tractor. Dealer inventory will be reduced, with the result that the hitch connection will be available—no delay.

Economy. There will be fewer hitches for the farmer to buy. It will not require a new hitch for all implements when changing to a new or different model tractor.

The foregoing are the more outstanding and important benefits to be derived from this program. In addition, many other benefits will be noted. We can indeed be proud of the efforts put forth by this society and its affiliates to relieve the entire implement and tractor industry of one of its most complex problems, and provide for many thousands of farmers an easier, more economical and a far safer means of operating power-driven farm equipment.

The U.S.D.A. Castor Bean Hullers

By I. F. Reed and O. A. Brown
MEMBER A.S.A.E. MEMBER A.S.A.E.

THE urge for the development of an efficient castor bean huller of relatively large capacity came about as a result of a federal government program for seed increase to meet the possible need for a large-scale production of castor beans in the United States for wartime purposes. Preliminary developments were discussed by E. D. Gordon in AGRICULTURAL ENGINEERING for June, 1943 (vol. 24, no. 6). Five hullers incorporating the principles discussed were built for the Commodity Credit Corporation and have been used extensively during the 1942 and 1943 hulling seasons. These hullers, processing about 30 bu of beans per hour, were very effective in doing the hulling job but needed simplification to make units more mobile. Development work was continued at the Tillage Machinery Laboratory of the U. S. Department of Agriculture, at Auburn, Alabama, during the 1942-43 fall and winter period.

This new huller is self-contained and mounted on a trailer so that it can be transported readily and is ready for service as soon as it is pulled to the job. The sectional view (Fig. 1) shows the simplicity of the huller and the arrangement of the working parts. The principle used is the same as that for the earlier models but the unit is made much more compact. This huller consists essentially of a self-contained power plant, a hopper and elevator unit, a vibrating feeder, a hulling unit consisting of cylinder and concave, and a separating unit made up of aspirator, fan, and vibrating screens. The arrangement is such that the parts performing one function can be revised or adjusted independently of the remainder of the machine, thus making it possible to adapt the machine to varying conditions and to get maximum effectiveness and efficiency under all conditions.

In operation the unhulled beans are dumped into the large hopper where the agitator causes a uniform flow into the cup elevator. The elevator dumps the beans onto the vibrating feeder which causes them to be distributed and fed uniformly to the cylinder. A high percentage of the beans is hulled as they pass between the rotating cylinder and stationary concave. The mixture of hulls, beans, and unhulled beans is discharged into the aspirator unit where the hulls and other light materials are lifted out by the upward air blast and discharged through the fan to the rear of the huller. The beans and heavy materials fall onto the screens in the separating shoe. The top screen retains the unhulled beans and discharges them into the elevator to make the circuit over again. The good beans are retained on the second screen and discharged into the bagger. Cracked beans and small particles of heavy trash pass through this lower screen and are deposited under huller.

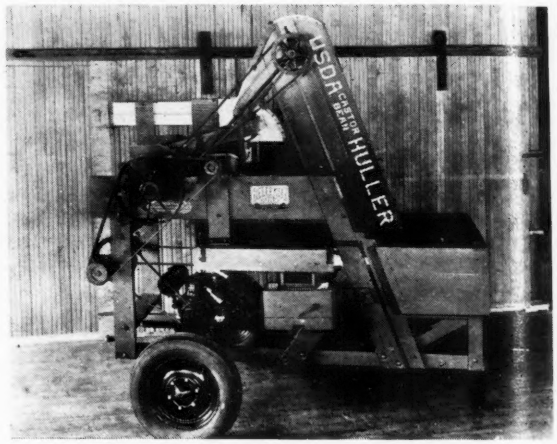


Fig. 2 The USDA castor bean huller as built by Belle City Mfg. Co.

The essential adjustments referred to above are rate of feed, clearance between cylinder and concave, strength of suction in aspirator, and vibration and clearance of screens. These adjustments permit selecting the best rate of feed, hulling clearance, and separation characteristics for the condition and type of beans. All adjustments are positive and need very little change after once set for the type and condition of beans found in an area.

The improved USDA castor bean huller is a neat, efficient, and effective machine that can be handled and supervised in operation by one man. Its capacity has been increased to between 35 and 40 bu per hr, yet the improved huller can be operated with a 2½-hp air cooled engine. Under normal conditions it cracks less than 2 per cent and the shelling percentage will be above 98 per cent. The number of light beans left in the hulled sample will depend upon the adjustment of the aspirator. This type sample is entirely satisfactory for planting seed or beans for oil mill purposes.

With improved transportation conditions this country was more or less assured of being able to obtain the needed castor beans from neighboring countries to the south so no additional hullers were needed to handle the 1943 crop in the United States. However, one of the 1942 model hullers purchased by the Commodity Credit Corporation was remodeled to incorporate the features built into the 1943 model huller.

Arrangements were made last year to permit the manufacture of twenty of the new machines for the government of Mexico and six for Pan American Industries, Inc. The production model patterned by the manufacturer after the USDA Tillage Machinery Laboratory development is shown in Fig. 2. These machines are in the hands of the purchasers and are aiding in getting the vitally needed castor beans hulled so that they can be shipped to the United States.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

I. F. REED and O. A. BROWN are agricultural engineers, Bureau of Plant Industry, Soils and Agricultural Engineering, U. S. Department of Agriculture.

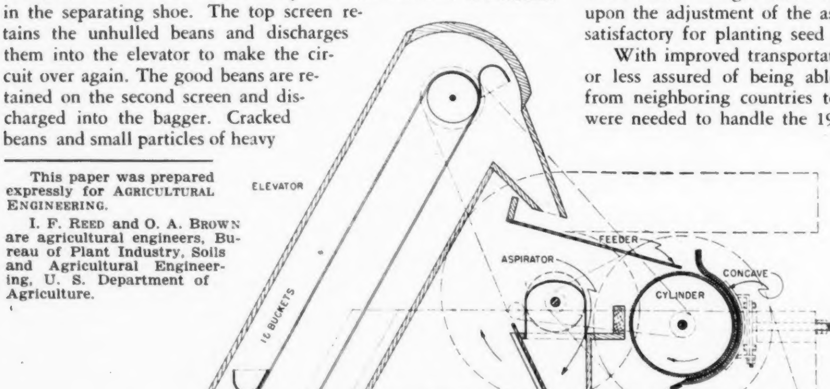


Fig. 1 A sectional view of the USDA castor bean huller showing components and their relationships.

Controlling Weeds by Flame

By Harold T. Barr
MEMBER A.S.A.E.

WEED and grass control by flaming has been practiced to a limited extent for a good many years. Clearing weeds from right of ways by large burners mounted on special trucks is common practice with some railroads. An examination of the U. S. Patent Office records reveals many patents on burners for use in killing weeds, sterilizing chicken houses, destroying weed seeds, burning prickly pears, and many other uses.

In railroad and drainage-ditch maintenance, large-volume, high-temperature burners will kill all the vegetation, including small trees. A burner unit consisting of a 3-hp engine, blower, fuel pump, fuel tank, and burner head was mounted on a turntable on a two-wheel cart. With such a mounting the burning can be either right, left, or directly behind the cart. The burner head being pivoted allows burning to the bottom of large ditches. If there is some dry or half-dry weeds and grass underneath, with standing green weeds or grass, once over at 1¼ to 1½ mph has given complete cleaning of the ditch. With a heavy green growth of Johnson grass 2 ft tall (and no trash underneath), a single pass at 1¼ to 1½ mph gives a complete kill to the ground. A second burn one week later completely destroyed all dry material and the green shoots then 4 to 6 in tall.

Johnson grass *(Sorghum halepense)* and alligator weed *(Alternanthera philoxeroides)* have encroached in some sections of the Louisiana sugar cane and rice areas at alarming rates during recent years. Labor shortage during recent years has caused less labor to be used in weed destruction and thus aided in the spread of these two pests. With soybeans planted in the spring and turned under in August, the infestation of alligator weed root rhizomes amounted to 10,904 lb per acre[1]. Flaming six times at biweekly intervals, commencing May 12, reduced the infestation to 395 lb per acre. Flaming twelve times at weekly intervals, commencing May 12, reduced the infestation to 157 lb per acre. Extremely heavy infestation of alligator weed resulted in a yield of sugar cane of 3.36 tons, while the same variety on corresponding soil, with no alligator weed, yielded 32.79 tons per acre. Fallow burning with present equipment requires from 1 to 1¼ hr per acre, consuming 28 gal of furnace oil per hour. A burner with a large hooded shield for confining the heat is now under construction for fallow burning.

That flame can also be used in row crops for killing grass and weeds in the drill row without injury to the crop itself does not seem possible. In the fall of 1941 and spring of 1942 a machine was constructed for trial in sugar cane in cooperation with one of our more enterprising sugar planters.

The first machine mounted on a tractor consisted of an air compressor, air tank, fuel tank, fuel pump, four burners, and the necessary connections. The burners were mounted on skid runners set for the flame to hit the base of the cane plants, covering both sides of one row and one side of each of two rows. Each burner consuming approximately 1½ gal of diesel or furnace oil per hour. With no previous work on sugar cane, several changes were made during the season in order to get the correct setting of the burners, type of burners, speed of travel, type of fuel, and to know how much burning sugar cane would withstand without injury. Eighteen tests including five varieties of sugar cane were staked out with check plots for the 1942 tests. The test and check plots varied from 0.33 to 2.6 acres per plot. The plots were each flamed three or four times with burners set 19 in apart and the flame hitting at the base of the sugar cane plant. A speed of 2 mph was used except where a very heavy growth of weeds and grass prevented a good penetration; in the latter case, the speed was reduced to 1½ mph.

A summary of the first year's results is shown in Tables 1 and 2. The sugar cane was examined immediately after burning and again on the second day after burning for scorched or wilted bottom leaves. In a few cases it was given a very severe burning and took on a golden brown color the second day after burning (Test 15); but this all disappeared in five days and at harvest the flamed cane out-yielded the hoe-cleaned plots by 1.3 tons per acre. Tests 1 through 7 (Table 1) were used for making all possible burner changes, and results indicate that it is possible to injure sugar cane by improper use of the flame. Tests 8 through 17 (Table 2) were run with slightly better and more uniform settings of the burners. Test 18 was not included in the summary because of the large difference in yield in favor of the flamed plot. This test consisted of two blocks of cane so heavily infested with water grass that at first it was thought best to plow it up. Only one block was flamed;

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Milwaukee, Wis., June, 1944, as a contribution of the Power and Machinery Division.

HAROLD T. BARR is head, agricultural engineering research, Louisiana Agricultural Experiment Station.

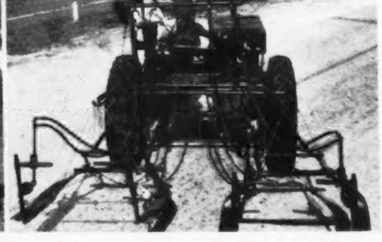
AUTHOR'S NOTE: The author wishes to acknowledge data submitted by B. C. Thomson, Thomson Machinery Co., Labadieville, La., J. C. Burden, Little Texas Plantation, and Bronier Tiebout, Greenwood Plantation, Napoleonville, La.

[1]Arceneaux, Geo., and Hebert, L. P. Fallow Flaming Promising as a Means of Controlling Alligator Weed on Sugar Cane Lands. Sugar Bulletin, vol. 22, no. 16, pp. 121-122 (May 15, 1944).

TABLE 1

		STALKS PER 10 FT OF ROW		YIELD PER ACRE, TONS OF CANE		BRIX		SUCROSE		PURITY	
TEST	VARIETY	Flamed	Check	Flamed	Check	Flamed	Check	Flamed	Check	Flamed	Check
1	29-103	73	68	25.7	25.3	17.45	17.74	13.56	13.66	77.71	76.52
2	29-120	85	86	24.8	31.2	16.66	17.71	13.52	14.37	81.18	81.16
3	29-120	91	89	27.0	30.1	17.03	16.49	13.68	13.69	80.34	80.81
4	29-120	84	84	25.5	26.7	16.71	18.10	13.51	15.57	80.82	86.01
5	29-120	83	82	26.4	29.7	16.65	17.37	13.21	14.50	79.32	83.49
6	29-120	85	80	27.1	28.1	16.85	17.16	14.00	14.03	83.11	81.77
7	29-120	78	83	24.7	27.5	16.00	16.97	12.45	13.85	77.82	81.60
Avg.		82.71	81.71	25.8	28.3	16.76	17.36	13.41	14.23	80.04	81.62

NOTE: This set of experiments was started without having any prior knowledge as to what should be the proper distance to set the burners, rate of travel, height of burners, etc. Consequently, the first and second applications of heat were different from what was later established as the proper distance to set the burners and rate of travel. The second factor entering into the results in this set of experiments was that the flame plots should have received one more flaming. Observations after lay-by showed checks to be far cleaner that flamed rows.



(Left) A flame machine removing grass and weeds from a drainage ditch • (Center) A one-row flame cultivator for two-mule hitch. Air pressure is maintained by hand power • (Right) A tractor-mounted, two-row flame cultivator equipped with power-take-off drive

TABLE 2

TEST	VARIETY	STALKS PER 10 FT OF ROW		YIELD PER ACRE, TONS OF CANE		BRIX		SUCROSE		PURITY	
		Flamed	Check	Flamed	Check	Flamed	Check	Flamed	Check	Flamed	Check
8	29-103	63	63	27.0	29.1	17.46	16.97	13.70	13.34	78.44	78.60
9	29-103	68	70	27.2	27.7	17.37	17.56	13.37	13.79	76.96	78.54
10	29-103	72	69	25.9	27.0	17.49	17.30	13.89	13.56	79.44	78.37
11	29-103	66	64	24.3	25.9	17.46	17.30	13.58	13.52	77.79	78.15
12	29-103	No readings		26.6	25.8	17.35	17.39	13.39	13.70	77.01	78.32
13	29-120	104	116	20.7	14.3	17.77	17.58	14.84	14.81	83.49	84.17
14	281	63	69	22.6	20.2	16.13	16.58	13.16	13.05	81.56	78.74
15	29-120	103	86	19.1	17.8	17.99	17.86	14.85	14.72	82.52	82.34
16	28-11	82	77	13.1	12.5	17.12	17.46	13.16	13.51	76.74	77.40
17	29-116	No readings		22.1	18.3	16.12	16.36	12.52	12.78	77.76	78.71
Avg.				22.8	21.8	17.22	17.23	13.64	13.67	79.17	79.33
18	29-103	No readings		24.8	12.6	17.75	17.56	14.25	13.81	80.28	78.65

NOTE: Burners in this set of experiments were set 19 in apart and rate of travel in most cases was 2 mph, except where alligator grass condition was bad or heavy growth of grass did not permit good penetration; then the rate was reduced to 1½ mph. In our opinion skipping of one burning between May 19 and June 13 would have given better results.

the other was hand hoed. The flamed plot was kept clean after the first flaming. The hand-hoed or check plots stayed full of water grass because the rains that followed hoeing made it impossible to destroy the vegetative growth of the water grass. The low yield in the check plot was due only to the large amount of water grass in it that could not be controlled by hoeing, which definitely illustrates the practibility of the flame cultivator in such extreme cases.

Each two-row flame cultivator is taking care of from 90 to 225 acres of cane, depending upon the amount of weeds and grasses. Most operators cover from 14 to 17 acres per unit in a 9-hr day. In 1943 one company had a yield of 26 tons of sugar cane per acre where no Johnson grass was found, and 17 tons per acre where Johnson grass had infested their fields. This company spent $17.50 per acre trying to control Johnson grass in 1942. This year they are flaming once per week for eight weeks. At the end of six weeks there was very little grass in the fields. With a normal acreage of 640 acres in sugar cane, 65 hoe hands were used. Today they have 14 old men, women, and boys. Hoe hands cover approximately ¼ acre per day and get $1.50, or an acreage cost of approximately $6.00 per acre to hoe once with heavy infestation. Cost of flaming on various plantations varies from 60 to 80 cents per acre for each flaming. This cost includes two men, tractor operation and depreciation, and burner fuel, but does not count burner depreciation.

There were twelve flame cultivators of one type or another in operation throughout the sugar can belt in 1943. This increased to approximately seventy in 1944, and one manufacturer who made forty-three of those in use in 1944 has on hand orders for one hundred more machines to be delivered in 1945. These orders were placed by the owners of machines now in use. Most plantations reported findings upon conclusions from a single season, and thought that different weather conditions may cause a variation in results. The general tone is that the operators are entirely satisfied and that the flame cultivator is a valuable and practical addition to their cultivating equipment. The flame cultivator is proving indispensable during the existing period of acute labor shortage and most operators believe that under normal conditions, with adequate labor available, the flame cultivator will prove more efficient and economical than hand hoeing.

TABLE 3. TOTAL YIELDS OF SEED COTTON IN FIRST PICKING FROM FOUR TREATMENTS IN A WEED-CONTROL EXPERIMENT, STONEVILLE, MISS., SIX REPLICATIONS, TWO CENTER ROWS OF 4-ROW PLOTS

Treatment	Seed cotton per acre, lb
Cultivation — no hoeing, no flaming	1506
Cultivation — no hoeing, flaming	2130
No cultivation — no hoeing, flaming	2033
Cultivation — hoeing, no flaming (plantation practice)	2141
Difference barely significant	196
Difference highly significant	271

With machine harvesting of sugar cane, tie vines have become a serious menace in some fields. These tie vines come up after the final cultivation. In order to destroy these late vines a special high-clearance model with 4 ft of clearance has been made and will receive its first test this coming fall.

Control of weeds and grasses in cotton by flaming was given a good test during the 1943 season at the Mississippi Delta Branch Experiment Station[2]. They found "no significant difference between the plantation practice and the flaming alone treatment or between the plantation practice and the cultivation and flaming combination treatments was obtained. A significantly smaller yield was obtained from the other treatments." Late in the season several acres of cross-cultivated cotton were flamed and the results indicated that this type of cultivation is well suited to flaming. A late flaming in place of the final cultivation would be less harmful to heavily loaded plants and provide just as clean a field for picking time.

[2]Neely, J. Winston and Brain, Sideny G. Control of Weeds and Grasses in Cotton by Flaming. Miss. Ag. Exp. Sta. Cir. 118 (March, 1944).

Placing Barrier Strips to Control Chinch Bugs

TO THE EDITOR:

IN AN article in AGRICULTURAL ENGINEERING for June, 1941 (page 218), A. L. Kennedy, associate agricultural engineer, Tennessee Agricultural Experiment Station, described apparatus used in making soil erosion studies. A part of the equipment shown was a belt-threading plow to place 6-in canvas belting edgewise in the ground so it protrudes 3 in above the ground as a border control strip.

It has been suggested that this plow might be used to place barrier strips in the ground for control of chinch bugs. It is very simple and inexpensive, may be fastened to the running board of any car, and with canvas will operate at ten miles per hour.

However, it is probable that canvas would not be satisfactory as a barrier strip, but it is possible that SisalKraft or some other form of building paper might be used, provided some material other than creosote were used to kill the bugs. The barrier material must be water resistant, and if it depends on asphalt for stiffness, something which will not dissolve asphalt must be used as a spray to kill the bugs at the barrier.

The migration of chinch bugs is not a problem in this area, but we would be glad to cooperate with anyone interested in using this device for placing barrier strips. It might be possible to arrange for the work to be done here, or we might make other arrangements for the use of the plow we have.

M. A. SHARP

Agricultural Engineering Dept.
University of Tennessee
Knoxville, Tenn.

This picture shows the belt-threading plow developed by A. L. Kennedy attached to the running board of a motor truck

Lighting Principles Applied to the Farm Home

By Helen G. McKinlay

LIGHTING for the farm house should be carefully appraised for its ability to perform at its functional best without waste but with light sufficient in amount and comfortable in kind wherever eyes are at work, since better "seeing" can contribute to saving time, labor, and conserving human resources.

Since during wartime restrictions have necessarily been placed on many vital materials, the further manufacture of lighting fixtures and portable lamps places certain limitations on their availability. Therefore in this paper the subject of lighting the farm home deals primarily with a discussion of basic lighting principles, and any allusion to lighting fixtures and portable lamps is used as an example of the lighting fundamentals involved.

Light for Seeing. In recent years many scientific facts have been developed with regard to light and its relation to seeing. The eyes are only a part of the complete "seeing machine" which includes the whole body. The complex process of "seeing" is made more difficult by poor lighting, and since seeing is a bodily function, there are resultant bodily reactions. When the eyes are under strain, the whole nervous system may experience ill effect. Headache and indigestion sometimes result from eyestrain. In the research laboratory actual measurements have been made of the unnecessary tenseness, fatique, and wasted nervous energy when eyes are used under poor lighting conditions. The sense of sight is helpless in discovering or even suspecting the deeply hidden effects of seeing. But the scientist with his systematic experimental approach and with devices aiding his senses can discover unobvious hidden causes and effects. Through scientific study and measurement of the ease of seeing, researches evolved from these findings which have opened new vistas toward new practices in better seeing with better lighting wherever controllable aid to seeing is involved. Many important facts have developed regarding the relation between light and sight[1].

Measured Light. It is advisable to use light in recommended amounts for the most satisfactory results especially where close eyework is done. These recommended amounts of light are measurable for assurance that the light is right. An instrument known as a light meter is available for this purpose, although it is not standard household equipment. Many utility companies and a number of home and county demonstration agents are equipped with light meters to help homemakers determine by measurement whether or not the light in the home is of recommended amount. Usually the recommended sizes of bulbs determine with reasonable satisfaction the amount of light which should be had throughout the home, but the light meter more accurately measures the light which falls on its light sensitive cell by registering the light which strikes it. Eyes are unable to judge lighting which is satisfactory for their needs, but the light meter is an excellent means of checking and testing the light since our eyes are incapable of determining safe seeing quantities with accuracy and assurance or to warn against inadequate amounts wherever visual work is carried on.

In the Illuminating Engineering Society Transactions, vol. XXIX, page 607, was published a list of "Recommended Foot-candle Levels for the Home," I suggested as a guide to assist with the minimum recommended amounts of illumination as shown in the following table:

RECOMMENDED LIGHTING LEVELS FOR THE HOME

	Foot-candles
Reading	
Prolonged periods with fine type	20— 50
Ordinary reading	10— 20
Sewing	
Fine needlework on dark goods	100 or more
Prolonged average sewing	50—100
Prolonged sewing on light goods	20— 50
Ordinary sewing on light goods	10— 20
Writing (ordinary)	10— 20
Card playing	5— 10
Children's study table	20— 50
Dining room (when used for ordinary reading or writing)	10— 20
Kitchen	
General	5— 10
Local at work counters and sink	10— 20
Bedroom	
General	2— 5
Bed light	10— 20
Dresser, vanity and dressing table mirrors	10— 30
Sewing machine	20— 50
Bathroom mirror	10— 30
Children's playroom	
General	5— 10
Local	10— 20
Stairways and stair landings	2— 5
Workbench	10— 30
Ironing machine, ironing board and laundry trays	10— 20

Quality of Lighting. The light meter only measures quantity of light, which is but part of the lighting consideration. The quality of lighting must also be carefully blended with quantity to produce the best results in comfortable seeing. Daylight offers an excellent example of these since daylight is generous in amount and soft and diffused by sky and clouds. From the valuable textbook of Nature can be found three important things, namely, the need for (a) diffused light, (b) "secondary" sources of light, and (c) good distribution of light.

(a) The best diffusion of light is obtained when the sky is clouded because harsh rays of the sun are diffused by clouds and scattered in all directions. The sky becomes a more even light source. Shadows on earth almost disappear because the light comes evenly from every part of the sky extending from horizon to horizon. By copying nature and "enlarging" the light source, lighting in a room can become more comfortable by diffusion. This can be done by reflecting some of the light to the ceiling, softening shadows and lessening the brightness of the light source itself.

(b) Remember that in nature the sun is the primary light source, the sky and the clouds are the secondary source. On a sunny day 80 per cent of the light comes from the sun and 20 per cent is reflected from the sky. But 20 per cent of the light reaching the earth is being reflected from the complete sky and it is this component of lighting which acts as a "secondary" source and provides relief from excessive contrasts. "Secondary" sources in a room may be had in several ways. The lamp shade is one. Its inner surface reflects light which adds softening effects to that produced by bare bulbs. Inverted fixtures hung so that light is reflected to the ceiling are also secondary light sources. The more light which escapes from table and floor lamps and ceiling fix-

This paper was prepared expressly for AGRICULTURAL ENGINEERING. It is a contribution of the A.S.A.E. Committee on Electric Light in Farm Production (Rural Electric Division).

HELEN G. MCKINLAY is home lighting specialist, General Electric Co.

[1] "The Science of Seeing", by Matthew Luckiesh and Frank Moss. D. Van Nostrand Co., New York.

tures to be reflected, the more soft will be the lighting result.

(c) The third contribution to quality of light is a good distribution of lighting in a room. Unpleasantness in lighting arises from contrasts and glare rather than from absolute values of illumination. Outdoor daytime contrasts are within reasonable bounds — contrast between sky and foliage may be eight or ten to one. Even this contrast between the light and shade areas of a building in strong sunlight will fall between 10 and 15 to one. Frequently discomfort indoors results from too much contrast rather than from too much light. Ratios which are too great in contrast are unpleasant and should be avoided. This unpleasantness can be eliminated by building up the light in the surroundings of a room to reduce unnecessary contrasts which frequently exist. General illumination from lighting fixtures are an aid to lessening this condition. Lamps and fixtures should distribute light upward to walls and ceiling and generally throughout a room.

Types of Lighting. Lighting equipment for the home is classified according to its manner of distributing light in a room. It provides direct lighting when the greater portion of its light is directed down upon the area to be lighted. Usually this type of lighting produces the highest foot-candle results compared with other types of lighting. Open reflectors of glass and metal come under this classification. Sharp shadows and glare frequently result unless precaution is taken to offset this unpleasantness. The use of totally enclosed globes which conceal the bulb also provide direct lighting since the greatest portion of light is directed downward. *Totally indirect lighting* directs all the light upward toward upper walls and ceiling which act as reflecting surfaces. For this reason white or very light walls will be more effective since light is lost by absorption if walls are dark. Inverted metal reflectors are the most outstanding example of lighting of this type. Totally indirect lighting is considered less practical and not so economical as installations which provide for some of the light to be directed downward through the fixture. *Semi-indirect lighting* is a combination of direct and indirect lighting. This type of lighting produces a comfortable effect and is obtained in a practical economical way. While the greatest percentage of light is directed toward the upper walls and ceiling, in addition some of the light from the fixture is emitted through the glassware or shading media itself to be usefully directed into the lower part of the room. This lighting is represented where inverted glass or plastic bowls are used, and portable lamps with reflecting bowls also come under this classification. Such lighting helps to reduce sharp shadows, harsh glare, and undue room contrasts.

Lighting Fixtures. A lighting fixture is recommended for every room in the home. Fixtures should be well selected to provide for comfortable and effective results. They should conceal the lamp bulbs and at the same time satisfactorily accommodate the needed wattage without glare. In low-ceilinged rooms they fit snugly to the ceiling, or in larger rooms, if suspended, they make use of the large ceiling as a reflecting surface. Ceiling fixtures provide for general lighting in a room, although they may also be selected for the purpose of localized lighting as well. In the utility rooms of the home such as the kitchen, laundry, and bathroom, or other work rooms where close eyework is done, such as is needed for use in study rooms or sewing rooms, lighting fixtures should be carefully selected for their functional performance. In the kitchen, work rooms, and bathroom, wall brackets well shaded and placed conveniently close to work surfaces can be a useful utility item in lighting consideration. The bathroom mirror is usually most satisfactorily lighted when a pair of wall brackets is used, one on either side of the mirror to provide for light on each side of the face.

Following is a brief discussion listing some of the considerations with regard to principles involved in practical application of lighting fixtures:

1 *Scale and proportion.* To be in scale and proportion with the room in which it is to be installed, when the diameter of a *fixture in inches* corresponds to width of the *room in feet,* a satisfactory appearance usually results. A room whose dimensions are 14x16 ft would appear well scaled if a 14-in diameter fixture of the single-unit type were used. When a fixture is installed consisting of several individual units grouped around a central stem (such as a candelabrum type), the length of a room is a good guide to follow.

2 *Hanging height of fixture.* Except fixtures mounted close to the ceiling or those used over dining tables, lighting fixtures should be hung with a 6 ft 6 in space between the lowest point of the fixture and the floor for clearance when walking beneath. Pendant type fixtures over dining tables should be mounted so that the light falls on the entire table top but that no direct light strikes the eyes of anyone seated at the table.

3 *Light distribution.* The type of lighting fixture to be selected (direct, semi-indirect, or totally indirect) should be determined by the room's activities. In utility rooms local lighting is usually needed and fixtures to provide that kind of lighting should be chosen, such as an enclosing globe for a kitchen or laundry. If predominance of downward lighting is desired, select a fixture which produces that result. In rooms where general lighting throughout is the end in need, such as lighting for a living room or bedroom, a fixture to distribute light generously on upper walls and ceiling could be considered.

4 *"Brightness" of fixture.* Sometimes fixtures appear too bright because the glassware of their lighted portion is too small for the bulb which is needed. Therefore, it is advisable to use the right bulb in the right-sized globe.

5 *Efficiency.* Six 25-w bulbs give the same amount of light as one 100-w bulb and use 50 per cent *more* current. Therefore, it is advantageous, when practical, to consider the use of fixtures which can utilize a single larger bulb instead of several smaller ones. Bulbs become more efficient as they increase in size.

The right wattage to use in lighting fixtures of various sizes and types can be determined by the type and dimension of the lighting fixture.

Portable Lamps. Table, floor, or pin-to-wall lamps are generally conceded to provide satisfactory "local" lighting for close seeing work, such as sewing, reading, or studying. Portable lamps are a convenient movable means of placing light close to the work areas. In order that lamps perform at their best, some guiding characteristics are given to serve their application, as follows:

1 Sufficient height and shade size to cast the light over a large and useful area.

2 The lining of the shade should be whit or light in color to reflect efficiently, even to as much as doubling the amount of useful light beneath.

3 Open top shades are almost always desirable except when lamps are placed on low tables and looking down into them may occur, or when used in stair wells where glare is disturbing and may cause missteps. Open shades provide for more reflection on upper walls and ceilings lessening harsh spotty contrasts in a room.

4 Shades should be dense enough to blend with their background and not stand out in contrast. Lamp shades light in color are suitable and satisfactory in rooms whose walls are light too.

Modernizing Old Lighting Equipment. Families in many homes are wholly dependent for light upon existing old type lighting fixtures and portable lamps of a variety which fall short of providing light according to today's standards now known to provide better light for more comfortable seeing. Within the past few years lighting equipment known as "adapters" and "conversion units" were developed for use on existing old type lighting fixtures and lamps. They were designed for use on drop cords, bare bulb fixtures, and table and floor lamps, and kerosene oil lamps. Today, however, these adapters are subject to the same limitation and shortage as is felt in the production of lighting fixtures.

Repair of Lighting Equipment. With the shortage of vital materials, it becomes more desirable than ever to keep all electrical equipment in repair. Sometimes the help of a qualified repair man is needed as in such instances when a lamp or fixture has to be "opened up". It is well to know what repairs can be made and what the symptoms are that indicate repairs are needed. Flickering lights, blown fuses, radio static when light is turned off or on, the failure of light to come on at first flick of the switch, fraying cords, looses plug connections and shocks received when touching parts of lamp or switch. The three most frequent causes of trouble are the switch, the cord (or other wires) and the plug. If lights come on only by wiggling a wall switch, if a pull cord has to be pulled again and again before the light goes on, or lights flicker, a repair man is needed. Repairing the cord and plug can be accomplished without his help. It is well to learn how to repair them and is an aid toward conservation and preservation of a very important home commodity.

New Techniques in Milking

By Dr. Geo. H. Hopson

FOR centuries hand milking has been the method employed to milk dairy cows. To be a good hand milker one has to be dexterous; therefore the number of good hand milkers has never been large. Most people have milked cows through necessity rather than for any pleasure derived therefrom. To perform a task well, one must like to do it. Hand milking is so wearisome and tedious that today fewer people are acquiring the art.

Milking cows by machine is the modern method; it has now become a science requiring thoughtful planning and a definite routine for every barn. The milking operation may be compared to an assembly line in a modern industrial plant. The cows are arranged in the milking line where they will respond best — the younger animals first and then the older ones, as the young animals milk more quickly. The older ones are milked last as what they see and hear may induce them to milk better and faster. Problem cows must be placed where they will not interrupt or stop this important "assembly line of production."

The milking machine technician must have all the equipment in good repair and at his finger tips, for once he has commenced his job of milking there must be no interference, as confusion on the part of the cows and the technician will result. Certain conveniences, such as a low cart to carry milk pails, stripping pail, water to wash udders, towel, strip cup, teat-cup dipper, etc., help to speed up the operation and eliminate the necessity of the operator carrying this equipment as he milks down a line of cows. A timing device is essential to better milking as it keeps the technician on his toes and the units are never left on the cow longer than necessary. Many timing devices are on the market, but the small glass 3-min egg timer is mostly used. It costs only a few cents and is available at most department and five-and-ten-cent stores.

The milking machine is an ingenious device. It is the only machine that is put on a living animal to perform a particular piece of work by itself. The milking machine is more than a labor-saver; it is also the best way to milk cows. It has been so perfected that cows milked by machine are breaking production records, and their performance compares favorably with results obtained by the best hand milkers.

The mechanical milker duplicates nature in substituting for the calf in many respects. Vacuum is applied to open up the teat and carry the milk away as with the calf's mouth. Uniform pulsations are employed so as to release the vacuum on the teat by collapse of the liner. This action is to allow the resumption of blood and lymph circulation in the teat, and is similar to the release of vacuum in the calf's mouth by sucking and swallowing. The milking machine has all the favorable qualities of calf-nursing characteristics, minus all the objectionable ones. The present-day dairy cow's udder is a sensitive overdeveloped organ and cannot withstand the oversevere nursing qualities of the calf.

If a cow fails to let down milk, there is no possible way for the machine to take it from her. It is therefore necessary to know a little about the phenomenon of milk secretion, which may be divided into two parts: First is the production of milk within the udder; the second part pertains to the letting down of the milk already formed. The letdown is the most important from the standpoint of successful mechanical milking.

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GEO. H. HOPSON is milk sanitarian and consulting Veterinarian, The De Laval Separator Co.

As the milk is made within the udder it is held in minute drops in millions of alveoli and recesses. Each alveolus, containing only a fraction of a drop of milk, is drained by ducts which coalesce with other ducts until they enter larger ducts and finally the cisterns above each teat. The droplet in each alveolus is too tiny to flow out of its own accord, so some pressure exerted from the outside is necessary to force it out. Surrounding each alveolus are small muscle cells that squeeze and expel the tiny droplets. The letting down of the milk may be best described as a conditioned reflex and directly due to a high intraglandular pressure caused by the presence of active oxytocin in the blood, which is responsible for the contraction of the alveoli and small ductule muscle. The failure to let down milk is similarly due to the pressure of adrenalin in the blood, which prevents the muscular contractions which are responsible for the high intraglandular pressure.

Under most circumstances cows like to be milked. Nearly all cows respond splendidly to mechanical milking if they are properly trained and prepared. The following simple rules if observed will result in better and faster milking:

1 Milk at the same time every milking. Cows are creatures of habit and milking on an exact schedule has a favorable effect on milk letdown and uniform daily production.

2 Have everything in readiness to start milking — milk cans arranged and cover lifted, strainers placed in the first cans to be filled. Avoid noise and confusion. Once milking starts do not attempt to do other jobs at the same time. Milking is no longer a "chore" but a full-time job, and requires the operator's full attention during the milking period.

3 Do not feed cows during milking, for under natural conditions the cow never grazes when the calf suckles.

4 Immediately before the teat cups are applied, udder and teats should be wiped with a clean cloth moistened in warm chlorine water of at least 130 F. This operation cleanses the udder, insures clean milk, and is a wonderful help in stimulating the cow to let down her milk. Manipulation of the udder with hot water is a substitute for the nursing action of the calf's warm moist mouth. This action stimulates the release of a hormone, which enters the blood stream and upon reaching the udder causes the small muscles to contract and squeeze out the milk into the gland and teat cistern.

Many cows will leak their milk, which indicates they are ready to be milked. Such animals should be milked first. Scientists agree that the cow has no direct control over the letting down of milk, but what she sees and hears and associates with milking will cause a favorable reaction, resulting in a perfect letdown of milk.

5 The next step is to draw a few streams from each quarter into a strip cup. This opens the natural seal on the ends of the teats and completes the process of preparation. The udder and teats will now be distended and this is the time to apply the teat cups.

The aforementioned steps take approximately a minute or less per cow. If this routine is followed all cows with normal udders should milk out clean in from 3 to 4 min. It is obvious that proper preparation saves time in the end.

When removing the teat cups at the end of 3 or 4 min, first put a small amount of pull on the unit with one hand, while the other hand manipulates and strokes the quarters. Only a few seconds are required to carry out this operation, which is called machine stripping. This method of stripping is rapidly gaining in popularity. Slow hand stripping often leads to slow milking habits in cows.

The manner in which heifers are first milked is often the determining factor as to whether or not they will be satisfactory milkers. Do not subject the heifer to the following milking procedure as many dairymen do: first, the calf; second, milking by hand; third, machine milking. By so doing the heifer will have gone through three transition periods. Milk her first by machine and she will respond splendidly.

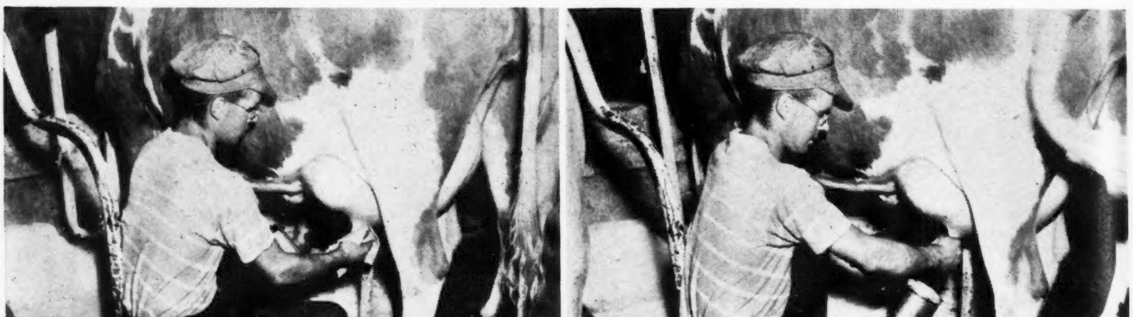
The occasional "problem" cow in a herd should be placed in the stanchion line so that she will be milked last and not interfere with the milking of the other cows. Cows with abnormal udders should be milked as advised by the veterinarian.

Care of and attention to the milking machine to keep it in perfect shape is most important to better milking. Low or high vacuum is a frequent cause of incomplete milking. The usual causes of low vacuum are a worn pump, clogged pipe line, worn or leaky stall cocks, or even a cracked pipe line. High vacuum is usually caused by a worn vacuum controller. Even though both conditions cause incomplete milking, they act differently in doing so. Low vacuum will not open up the meatus of the teat sufficiently to allow a large stream of milk to flow, nor will it take what milk there is away with sufficient speed. High vacuum may cause enough congestion and irritation on the ends of the teats so that the cows will not let down their milk. High vacuum used over an extended period of time will cause a chronic thickening of the end of the teat, resulting in what sometimes is called a spray teat or a partial obstruction of the teat opening. Frequent checking of the vacuum with a tested gauge is very important and should be done at least once a year.

The teat cups are the only part of the milker that come in direct contact with the cow's udder and teats and should be given especial attention. The liners should be kept at the correct tension so that the cows are milked in the same way every day. Two sets of liners should always be used, rotating the sets every seven days. Two sets used in this manner will not only milk much better but should last longer than two sets, and perhaps three, used continuously.

Cows respond to the minutest change, such as a gradual change in the loss of elasticity in the liners. The change is so gradual that it may not be noticed by the operator until its effect is shown after a period of time. Unfortunately cows cannot be relieved or broken of their bad milking habits as quickly as a mechanical condition can be corrected. It is much more satisfactory to keep the equipment in good repair and save the time and energy of retraining the animals over again.

Milk of the highest quality can be produced with the milking machine. Nearly all certified and premium milks are produced in this manner. Dairymen today are better equipped to care for their milkers. Hot water heaters, washing powders, chemical and hot air sterilizing cabinets aid in keeping the equipment clean and commercially sterile.



(Upper left) Before applying teat cups, udder and teats should be wiped with a clean cloth moistened in warm chlorine water of at least 130F. This operation cleanses the udder, insures clean milk, and is a wonderful help in stimulating the cow to let down her milk • (Upper right) Next a few streams are drawn from each quarter into a strip cup. This opens the natural seal on the ends of the teats and completes the process of preparation • (Lower left) Applying the teat cups is the third step. The first three steps take approximately a minute or less per cow • (Lower right) Manipulating and stroking quarters (machine stripping) prior to removing the teat cups. Only a few seconds are required carry out this operation of machine stripping. This method of stripping is rapidly gaining in popularity. Slow hand stripping often leads to slow milking habits in cows

China Must Have Agricultural Engineering

By P. W. Tsou

CHINA has a gross area of 4,447,000 sq mi, or about 2,846,000,000 acres, including twenty-eight provinces and the special areas, Tibet and Mongolia. The total land under cultivation in twenty-seven provinces, excluding Sikang, is about 230,244,000 acres, or about 12 per cent of the total area of these provinces. The total population of China is approximately 450,000,000. At least 360,000,000 people, or about 80 per cent of the total population, are engaged in farming. At this point, one can readily see the serious problem of high population pressure in China, especially on the farm land. The farm population per square mile of crop area is found to vary from 900 to 1,900, some districts having as many as 4,000 persons.

This situation has produced the inevitable result of small farms. The usual size of a farm in China is only four acres, the income from which cannot and has never been enough to provide the farmer and his family a decent living. For this apparent reason, the size of farms in China will have to be enlarged as a first step towards elevating the farmer's level of living. We should like to see the day when Chinese farmers expand their farms ten times, from four acres to forty acres.

When the size of farm is increased, the farmer must be ready to make adjustments to the change. He must be provided with enough implements and machines to operate his larger acreage. The present available equipment on farms is far from adequate. China needs a group of inventive agricultural engineers to improve all the hand tools and animal-drawn implements, and to introduce tractors, especially in the big flat lands of Manchuria and northern and northwestern China. Wherever farmers cannot buy the equipment individually, they should organize cooperatives to own and operate such implements and machines jointly.

At present, China is planning and preparing for postwar industrialization. As industries grow, they will have increasing need not only of capital and management, but also of a large supply of labor. The labor will have to be recruited from rural areas. This means that there will inevitably be a decrease in rural population. Where that occurs, the farmer will have to resort to labor-saving implements and machinery to compensate the loss of labor. Today the Chinese farmer operates a small farm with plenty of help; tomorrow he will operate a large farm with less help, and he will be expected to produce as many if not more products. The only remedy will lie in the improvement of existing implements and the mechanization of farms. The industrialization of China is a blessing to agriculture provided that the agricultural engineers can furnish the farmers with adequate implements and machines to offset the changed situation.

While we should like to see big factories established in the cities of China, we also want thousands of small manufacturing and processing plants erected in rural districts. The development of rural industries will provide employment for the farmers, especially in the slack season, thus giving them opportunities to earn extra income. The bulky farm products can be processed or semimanufactured in the production area so as to save volume, tonnage, and cost of transportation which ultimately will result in savings for the city consumers. The machinery for such industries as sugar refining, cotton ginning, fruit and vegetable canning and dehydration, and the like will have to be designed by the agricultural engineers to suit the rural conditions in China.

Farm housing, farm storage, and handling of farm manure will also need the inventive genius of agricultural engineers to make the designs and to discover the proper materials for construction. The construction should be simple, yet economical and sanitary.

All of this requires the work of agricultural engineers, and it explains why China must have agricultural engineering.

How can China best develop agricultural engineering? The program of agricultural engineering, from the government point of view, is one of many agricultural problems. It should be promoted side by side with such other programs as agricultural research, extension, education, and credit. In China today there is a good bureau of agricultural research, a few well-organized provincial agricultural experiment stations, seventeen agricultural colleges (private and public), a board on agricultural extension, a strong farmers' bank with branches in practically all provinces. What is needed now is to strengthen the above organizations and to adopt a sound system for the coordination of their work.

There are four things which require immediate action in connection with agricultural engineering as follows:

1 A department of agricultural engineering to be established in the National Bureau of Agricultural Research. In that department, at least two American experts should be invited to start the research program in agricultural engineering.

2 A department of agricultural engineering to be established in the college of agriculture of the Central University. At the same time, the government should help strengthen the existing department of agricultural engineering of the college of agriculture of Nanking University. In each of these two institutions, at least one American expert should be invited to push the educational program in agricultural engineering.

3 A program of training 90 Chinese experts in agricultural engineering to be started immediately by sending over to the United States thirty selected college graduates in that field for the next three years. These men should spend at least three years in America — two years studying in school and one year training in factories and on farms.

4 Some of the most successful American farm equipment manufacturers should send representatives to China to study the possibilities of organizing companies there, preferably joining forces with Chinese industrialists or the Chinese government.

With due encouragement and effort on the part of the Chinese government, the following accomplishments should be expected within the next seven years:

1 A strong department of agricultural engineering established in the National Bureau of Agricultural Research. The country might be divided into twelve regions. In each region, there should be a national agricultural experiment station, each with a department of agricultural engineering of similar nature but less scope than that of the Bureau.

2 In the same localities as the national agricultural experiment stations, twelve national agricultural colleges should be established, each with a strong department of agricultural engineering.

3 A central office of agricultural extension incorporated in the Ministry of Agriculture and Forestry, with twelve regional offices set up in the same localities as the above-mentioned stations and colleges. The extension offices should lay due emphasis on agricultural engineering in their extension programs.

4 Ninety Chinese experts of agricultural engineering, having completed their training in the United States, assigned to important positions in the above institutions.

5 Hundreds of college graduates in agricultural engineering from the twelve proposed agricultural colleges engaged in the important work of teaching, research, extension, and the manufacturing of farm implements and machines.

6 Several good manufacturing concerns established in China turning out the necessary implements and machines for Chinese farms, farm families, and rural factories.

7 A good system of rural credit which, among other activities, will finance the farmer and his cooperative in buying the necessary implements and machines.

Only when these seven points are successfully carried out will we have the men and organizations to develop agricultural engineering on a nation-wide scale for the benefit of our millions of farmers. The program must be started now.

This is an address delivered before the annual meeting of the American Society of Agricultural Engineers at Milwaukee, Wis., June, 1944.

P. W. Tsou is president of the Agricultural Association of China and resident representative in the United States of the Chinese Minister of Agriculture and Forestry.

Weed Control with Chemicals

By John F. Benham

ASSOCIATE A.S.A.E.

WEED control on agricultural lands has been one of man's historic problems in the production of food. In the early mechanization of agriculture, the agricultural engineer developed tools for weed control even more rapidly than those for seeding and harvesting.

The weed problem is becoming more intensified rather than lessened because new weeds have been introduced, a high percentage of our crop land is made into a seedbed regularly which is conducive to weed as well as crop growth, and the prevalence of insects such as the European corn borer has necessitated the reduction of the weed population in waste areas on the farm. Some engineering developments such as the combine have actually intensified the necessity for better weed control. Laws in many states now require that landowners prevent the reseeding and spread of noxious weeds.

The most important methods of weed control are still those of good cultivation, use of clean seed, etc. However, there are important untillable areas on and off the farm such as fence rows, ditch banks, roadways, firebreaks and railroad rights-of-way where mechanical means of killing weeds are impossible or inadequate. Control without cultivating is desirable in other areas including pastures, lawns, athletic fields, golf courses and parts of fields where cultivation would destroy the crop. Some weeds with underground root systems, such as bindweed, Canada thistles and quack grass, are very difficult to eliminate by ordinary means, and improper cultivation may actually contribute to their spread.

Weed killing in new methods of crop culture may bring about revised concepts of our weed control problem. I quote Dr. E. G. McKibben in AGRICULTURAL ENGINEERING for February, 1944: "In the field of tillage and cultivation current studies of the mulch culture program in the more humid sections indicate the need of equipment to give better weed control."

Chemicals have been used for many years for special weed control problems. Indicative of their future use may be the fact that in some states chemicals are being used to weed onions and carrots. There is a definite need and place for the further development of equipment for the killing of weeds by other than mechanical means.

Our railroad weed control problem is quite similar to that found on many parts of the farm in that mechanical cultivation is quite impractical. It is necessary to remove such undesirable growth by hand, fire, or chemicals. We have a large acreage all of which represents more or less of a weed problem. The Pennsylvania Railroad trackage alone is over 26,000 miles. It is necessary that we control weeds in roadbeds to facilitate drainage, increase life of ties, and reduce fouling of ballast which would otherwise result in rough track. Inability to rid tracks of vegetation would increase labor requirements by tens of millions of unavailable man-hours per year. It is also necessary to control weed growth on rights-of-way, not only for the sake of appearance but to prevent their spread to adjacent farm land. For safety's sake, weeds must be kept down in yards along tracks where trainmen walk. Increased traffic, labor shortages and difficulty in obtaining normally used weed-control materials have complicated the problem for us during wartime.

Our experiences are related here as indicative of the job requirements, possible methods and type of materials to be used in control of weeds by the use of chemicals. From this we may be able to derive a better conception of the engineering job to be done.

In selecting chemicals, the colleges, the U. S. Department of Agriculture and chemical companies were canvassed in order to put on test those chemicals which had appeared most promising for weed control. More than 50 chemicals were specifically mentioned as of value in weed control but only eight of the more frequently mentioned were selected for this work, including ammonium sulfammate, borax, borax and caustic soda, fuel oil and creosote, salt, sodium arsenite, and sodium chlorate.

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JOHN F. BENHAM is agricultural agent, Pennsylvania Railroad.

Weed killing chemicals fall into three general classes according to the way in which they work. The soil sterilants inhibit weed growth through being incorporated in the soil by solution and coming in contact with the roots. Examples of soil sterilants are borax and salt. There are those contact killers which destroy the foliage in much the same manner as a weed burner. A mixture of fuel oil and creosote is of this class. The third class includes those which are both contact killers and soil sterilants. Examples are ammonium sulfammate, borax and caustic soda in combination, sodium arsenite, and sodium chlorate. Contact killers are usually applied as a spray in order to adhere to the foliage of the plant. Soil sterilants may be applied in the dry form and go into solution with the advent of rain.

My personal experience with our railroad in the use of chemicals in weed control has been that of testing the above materials on our tracks near Richmond, Indiana, and in assisting our test department in applications and observations at various other points.

Our principal conclusions have been as follows: (1) Weeds can be controlled with any chemical—*if enough of it is used.* (2) We have not yet found the chemical which, when used in practical amounts, will give sufficiently satisfactory total weed control for more than one year, although the nature of the vegetative population may be materially altered from such annual treatments.

On the test areas sweet clover was our worst weed. Others included bindweed, wild carrot, bouncing bet, wild parsnip, alfalfa, various grasses and cereals, and a general mixture of annuals. Soil conditions have been typical of roadbeds in being friable, low in fertility but sufficiently alkaline to support sweet clover.

We have 27 plots treated with borax in seven locations in amounts ranging from 8 to 32 lb per sq rd. Fairly satisfactory control has been achieved with 10 lb per sq rd per year. Annual spring applications have been necessary, although even with less frequent treatments the trend in weed population has been downward. The results have been better on heavier soils, presumably due to correlation with leaching. On one area of 270 sq rd in a switching yard, 10 lb of borax were used in the spring of 1942 and again in 1943. Comparisons with the adjacent untreated area indicate a reduction of 87 per cent in sweet clover and 65 per cent in total weed growth composed largely of mixed grasses and cereals spilled from cars.

The other soil sterilant, salt, has been effective only on the poorly drained heavy soils of a branch line in upstate New York supporting a heavy growth of quack grass. Here amounts ranging from 30 to 180 lb per rd were used. Annual applications of 60 lb per sq rd produced satisfactory control. Failure to continue annual applications, however, permitted the appearance of sweet clover in areas formerly occupied by quack grass.

A mixture 9 parts of fuel oil and 1 part creosote was the only strictly contact killer used in these tests. However, this mixture has been used rather extensively by our and other railroads prior to the war at 1 gal per sq rd. This treatment has been very successful in deadening all surface vegetation quickly and at low cost. Similar in its action to burning, new growth quickly reappears.

Ammonium sulfammate has been observed for three years at 1 to 3 lb per sq rd and has been satisfactory for weed control. Applied as a spray, surface vegetation is slowly deadened with a carry-over effect from soil sterilization. While the nitrogen content of this material may in time stimulate plant growth, the above amount has inhibited weed growth for one year until subsequent applications were made.

Borax and caustic soda has been used as a spray by dissolving 5 lb of borax and 2½ lb of caustic soda in 1½ gal of water and applying on one square rod. A quick surface kill on sprayed vegetation and a limited soil sterilization effect was observed.

Sodium arsenite at 3 lb per rd as a spray was fairly satisfactory and economical as a contact killer and soil sterilant. Its use for railroad work is extremely limited because of its poisonous properties to both man and beast.

Sodium chlorate (used in form of Atlacide) has also been rather extensively used by railroads. *(Continued on page 304)*

Some Field Applications of Water Transmissibility and Storage Coefficients

By Raphael G. Kazmann

THE consolidated and unconsolidated rock formations of the earth are great natural underground reservoirs and conduits from which a part of the water originating as rain or snow serves to supply wells and springs and to maintain the flow of streams during periods of fair weather. The hydrology of these formations has been studied for a number of years[2, 3, 4, 5, 6]*, yet only in the past decade have methods been developed to express in quantitative terms the ability of the formations to act as reservoirs and conduits.

The ability of a formation to yield water from storage is measured by its "coefficient of storage," which is defined as the quantity of water, in cubic feet, yielded from each vertical column of the aquifer with a base of one square foot due to a drop in water level of one foot. For water-table conditions the coefficient of storage is equal to the specific yield and is only slightly less than the porosity for sands and gravels, but considerably less than the porosity for clays and silts. For artesian conditions the coefficient of storage is the quantity of water yielded from storage by the compression of a column of the water-bearing material and its associated fine-grained beds.

The ability of a water-bearing material to transmit water is measured by its coefficient of permeability and the corresponding ability of the formation to transmit water is measured by its coefficient of transmissibility. For a given formation the coefficient of transmissibility is simply the coefficient of permeability multiplied by the thickness of the formation in feet.

The unit of transmissibility is one gallon of water per day through a cross section of aquifer one mile wide under a gradient of one foot per mile. Inasmuch as the transmissibility is inversely proportional to the viscosity of water, in comparing one aquifer with another it is necessary to correct the transmissibilities determined from field tests to the same temperature or to a standard temperature. A standard temperature commonly used is 60 F.

The first use of permeability coefficients determined from field tests is believed to have been made by G. L. Thiem in connection with an investigation of the water supply for Prague, Czechoslovakia, the report of which was published in 1906. Thiem applied the coefficients of permeability of the formations in that area to the quantitive problems of water supply.

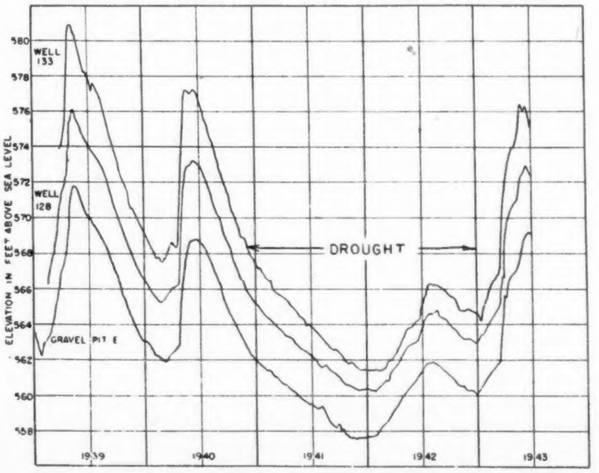
Until 1930, however, only scanty records existed on either the determination of permeability by field tests or the application of permeability to practical problems. In 1930 and 1931 L. K. Wenzel, as part of an investigation of the ground-water resources of the Platte River Valley in Nebraska, made several intensive pumping tests from which the coefficients of permeability and the specific yields of the formations were determined. A description of the work on permeability and specific yield was published in 1936[9]. Probably the most important contribution of that investigation was the standard field procedures established by Wenzel, by means of which comparable results can be obtained at any place at which the geology of the water-bearing beds approximates the assumed theoretical conditions. The formulas used in determining the coefficient of permeability were of the "equilibrium" type; that is, the formulas were valid only over that part of the cone of depression near the discharging well that essentially had reached a constant form. A factor for time was involved only to the extent of the time of pumping required for the cone of depression to reach a constant form in the vicinity of the observation wells. The coefficient of storage was determined for various periods of pumping from the hydraulic gradients, the volume of material unwatered, and the volume of water pumped.

In 1935 C. V. Theis, with the help of Professor C. I. Lubin, derived a formula to relate the drawdown of the piezometric surface at any point with the permeability and thickness of water-bearing sand, the storage coefficient of the aquifer, the number of days since the well began to discharge, and its rate of discharge[7]. This advance in theory has been followed by field tests in many parts of the country to determine the transmissibility and storage coefficients of numerous water-bearing formations under a variety of geologic and hydrologic conditions. The Theis formula has been applied and verified many times. Some of the results of this work have been published in short papers which have appeared for the most part in the transactions of the American Geophysical Union between 1935 and 1943. These papers add to the theoretical background and technique of the determination of the coefficients and give, in very general terms, the results of a number of tests of differing durations and with varied conditions of pumping. In 1942 a paper by L. K. Wenzel summarized the methods for determining permeability of water-bearing materials and made available to the engineering profession details of the techniques involved[10].

The urgent need for reliable supplies of ground water for new or expanding war industries has resulted in a concentration of effort on the practical application of these quantitative studies. The application of the coefficients of transmissibility and storage to practical problems is, therefore, a development that has been concentrated for the most part in the last three years. The purpose of this paper is to explain how these coefficients can be applied to field conditions and what practical results may be reasonably expected. Several case histories of investigations and applications with which the author is personally acquainted are cited.

Arkansas. The Grand Prairie region of Arkansas comprises an area of about 1,000 square miles and is located principally in Arkansas, Prairie, and Lonoke Counties. Rice has been grown in the region since about 1905, and the principal source of water for irrigation has been the Pleistocene sands and gravels that underlie the Prairie at depths ranging from 30 to 250 ft.

Since 1928 the U. S. Geological Survey has been studying ground-water conditions in the Grand Prairie, first in cooperation with the Arkansas Geological Survey and more recently with the Arkansas Agricultural Experiment Station. The Federal Land Bank of St. Louis has also been interested in the investigation because of the relation of ground-water supply to land values.



Curves showing fluctuations of water level at three points in the Miami Valley south of Hamilton, Ohio

This paper was presented at a meeting of the Southwest Section of the American Society of Agricultural Engineers at Dallas, Texas, March 10, 1944.

RAPHAEL G. KAZMANN is hydraulic engineer, U. S. Geological Survey.

*Superscript numbers denote the references appended to this paper.

The water levels in some wells in the Grand Prairie have declined as much as 20 ft since the investigation started, and the yields of some of the wells have decreased appreciably. The principal problem in the region may be summarized as follows: How many acres of rice is it possible to irrigate each year for an indefinite period of years without ultimately exhausting the supply?

Pumping tests were conducted in 1940, 1941, and 1942 at several localities in the Grand Prairie region for the purpose of determining the coefficients of transmissibility and storage of the water-bearing beds. The coefficients of transmissibility, in conjunction with contour maps of the "piezometric" or "pressure" surface, can ultimately be used to determine the quantity of water entering the Grand Prairie region from its periphery each year. This will only be possible, however, after enough tests have been made to give a good sampling of the transmissibilities existing on the periphery. The storage coefficients obtained from the pumping tests can be checked by comparing the volumes of water pumped from the Pleistocene sand with the volumes of material that have been unwatered each year and the quantities of water that percolate into the region. The investigation has not yet been completed, but when the perennial yield is determined, appropriate action can be taken to guard against overdeveloping the supply.

Ohio. The Mill Creek Valley is south of Hamilton, Ohio, and extends southward through Cincinnati to the Ohio River. It is a valley filled with glacial outwash, gravel which is covered at most places with a blanket of clay. The valley of the Miami River touches the north end of Mill Creek Valley in the vicinity of Hamilton, Ohio, and the water-bearing beds of both valleys are interconnected and more or less continuous.

The concentration of industries in the central and southern parts of the Mill Creek Valley has produced a serious water-supply problem, as the industries are using large volumes of water from the gravels for cooling purposes and in various industrial processes. An average of approximately 15 or 20 million gallons of water per day has been obtained from the gravels in the lower Mill Creek Valley over a period of years, and as this quantity of water exceeds the perennial safe yield there has been a more or less progressive decline in ground-water levels in the valley.

With the advent of the war, federal funds were advanced to the Wright Aeronautical Corporation to build an airplane engine plant in the Mill Creek Valley near Lockland, Ohio. This plant was designed to use over 10 million gallons of ground water a day, which was in addition to the water already being pumped from the underground reservoir. In 1942, with ground-water levels declining rapidly, the Federal Works Agency decided to develop a new water supply for the Wright Corp. outside the Mill Creek Valley. On the basis of previous work of the Geological Survey in the area, it was decided to construct supply wells in the valley of the Miami River south of Hamilton and to convey the water by means of a pipe line to the Wright plant in Lockland. The City of Hamilton, however, fearing that its ground-water supply would be endangered by the proposed pumpage, protested against the location of the well field. As a result the Federal Works Agency requested the Geological Survey to determine the safe yield of the new well field and to keep a close watch on the effect of the pumpage from the field on water levels in the Hamilton area. For this purpose a number of 6-in observation wells were drilled in the new well field, and in the Hamilton area, and arrangements were made to measure water levels in domestic wells in the well field area, in order that maps of the piezometric surface could be drawn.

Several pumping tests were conducted to determine the transmissibility and storage coefficients of the water-bearing formation. Old records of water-level fluctuations were reexamined in the light of new information obtained from these tests, in order to determine the safe yield of wells in the area. The pumping tests gave values of transmissibility ranging from 350,000 to 450,000 gpd. At one place in the center of the well field, about two miles from the Miami River, a pumping test gave a storage coefficient of about 0.23.

The average annual fluctuation of water level in the valley over a five-year period had been found to be about 8 ft (see accompanying curves). Using the storage coefficient determined from the pumping tests, this annual fluctuation was made the basis for calculating the quantity of water perennially recharging the aquifer from precipitation and gave an average of about 13 million gallons a day in the whole well-field area.

A pumping test was made near the Miami River and the coefficient of storage was found to increase indefinitely with the period of pumping, owing to recharge from the river. Thus it was inferred that the lowering of the piezometric surface or water table in the vicinity of the river would induce percolation of water from the river to the well field and provide a source of recharge in addition to the precipitation.

On the basis of theoretical work done by C. V. Theis[8], it was found that, with the existing arrangement of wells in the field, a total of about 6.5 million gallons per day of river recharge could reasonably be expected in addition to the estimated normal recharge from rainfall of 13 million gallons a day.

The report of the Geological Survey served as a basis for the Federal Works Agency's plan to pump 15 million gallons per day for an indefinite period with the assurance that the ground-water supply of the City of Hamilton would not be seriously affected. In addition, the report included a proposed cycle of well-field operation designed to produce maximum quantity of low-temperature water from the well field with the minimum effect on water levels in the Hamilton area.

In reviewing this investigation, it may be seen that the coefficients of storage and transmissibility were used in determining annual recharge from rainfall, and the rate of infiltration of water from the Miami River into the well field under certain conditions, and in planning the location and rates of withdrawals of water.

West Virginia. A large war plant in West Virginia was designed to obtain its water supply from Ranney type wells constructed on the banks of the Ohio River. After a preliminary period of operation, the yields were found to be lower than anticipated, and the authorities began to suspect that possibly after a period of time the ground-water reservoir might be pumped dry. It would then be necessary to build a large filter plant and to install a large amount of water-conserving equipment. However, before beginning to construct a filter it was decided to request the Geological Survey to determine the source of the water pumped by the wells and the probable minimum yields to be expected under adverse conditions of operation.

Observation wells were put down in the vicinity of the producing wells, and the coefficients of transmissibility were determined from pumping tests. Contour maps of the piezometric surface during pumping were drawn, and records were kept of the river levels and temperature, of the quality and temperature of the water issuing from the wells, and of the rainfall. By means of planimetering contours it was found that the coefficient of storage of the water-bearing material near certain wells increased indefinitely with the pumping, and it was concluded that the river furnished the bulk of the water pumped. For example, for the period April 25 to May 11, 1943, 6,400,000 cu ft of water was pumped from well P-5 and approximately 10,500,000 cu ft of the aquifer was unwatered. This would give a storage coefficient of about 61 per cent—much higher than the porosity of sands and gravels comprising the water-bearing formation. Inasmuch as no rain fell during that period, it was concluded water must have infiltrated from the river. This conclusion was corroborated by an appreciable variation in temperature and water quality during the period of investigation.

From a study of the contour maps the reaches of the river in which infiltration into the adjacent water-bearing beds occurred were delineated. It was found that in the vicinity of two production wells little if any recharge occurred from the river, but that near four other production wells river recharge did occur. The Theis formula was used to determine the period of pumping required to produce equilibrium flow, and calculations were then made of the minimum yield expected from each well. Provisional estimates of recharge from rainfall were made from a short record of water-level fluctuations in a well unaffected by pumping.

The results of the study were furnished the plant operators to aid them in planning their water conservation program and in determining whether a filter plant would be necessary. The filter plant was not built, although cooling towers were found to be needed. Ground-water conditions at that plant are still under observation for the purpose of determining how closely the predictions made from the study correspond to the facts as determined from a long period of operation.

SUMMARY

Definitions and a brief history of the determinations of transmissibility and storage coefficients have (Continued on page 304)

Baffle Type Energy Dissipator for Pipe Outlets

By Vito A. Vanoni and James T. Rostron

THE baffle type energy dissipator described in this paper was developed through laboratory experimentation for use in soil conservation work. It is designed to reduce the energy in high velocity pipe flow so that the water may be discharged safely into an erodible channel. This structure can be adapted to meet the many field conditions encountered in erosion control work in agriculture and elsewhere, such as at pipe outlets draining terraces or ditches, highway culverts, and drop inlet spillway outlets. Pipe sizes commonly used in such applications range from 10 to 48 in in diameter and have flows from 10 to 250 cfs discharging into channels of various widths.

The design of a baffle type dissipator was first worked out in 1938 by the engineering division of the Soil Conservation Service at Berkeley, California, in an attempt to devise a system of energy dissipation for high velocity flow from pipe outlets that would be more economical than that which makes use of the hydraulic jump. Fig. 1 shows the general appearance of such a structure.

Considerable need for these structures has been encountered in the field and since the originators of the design were not satisfied with it, the Cooperative Laboratory of the Soil Conservation Service and the California Institute of Technology was requested to study the problem and to develop complete design formulas for a structure that could be used generally. The work at the Cooperative Laboratory was undertaken in November, 1941, on a program of laboratory tests which covered the many combinations of discharge, structure width, and pipe size encountered in the field.

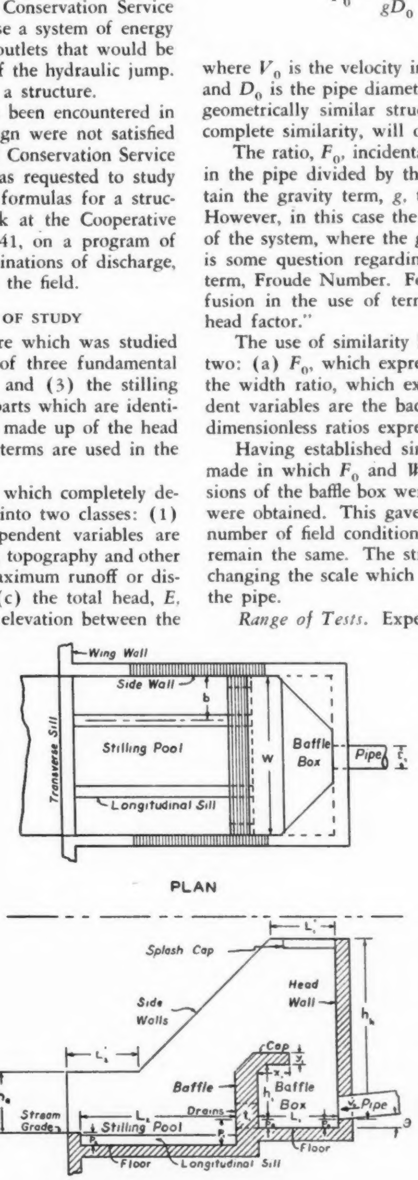
OUTLINE OF PROBLEM AND SCOPE OF STUDY

Elements of Structure. The baffle structure which was studied and which is shown in Fig. 1 is made up of three fundamental elements: (1) the pipe, (2) the baffle box, and (3) the stilling pool. Each of these elements is made up of parts which are identified in Fig. 1. For instance, the baffle box is made up of the head wall, floor, baffle, cap, and sidewalls. These terms are used in the text without further definition.

Identification of Variables. The variables which completely describe the structure and its performance fall into two classes: (1) independent and (2) dependent. The independent variables are those determined by field conditions including topography and other characteristics of the site, such as (a) the maximum runoff or discharge, Q_0, (b) the length, l, of the pipe, (c) the total head, E, on the system measured by the difference in elevation between the water surface at the entrance to the pipe and at the end of the pipe, and (d) the width, W, of the structure. Of these variables all except Q_0 are subject to some adjustment by modifications of the general layout of the system in the field. However, once they are fixed there is only one structure that will fit the conditions, and therefore all dimension are determined. The main dependent variables are the diameter of the pipe, D_0, and the static pressure, h_0, at the end of the pipe, which is referred to as the "back pressure". Other dependent variables are the dimensions of the structure, shown in Fig. 1. Essentially the problem of the laboratory study is to determine the mathematical relationships between these dependent and independent variables.

This paper was presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1943, as a contribution of the Soil and Water Division.

VITO A. VANONI and JAMES T. ROSTRON are, respectively, research project supervisor and assistant hydraulic engineer, Cooperative Laboratory (cooperative with the California Institute of Technology), Soil Conservation Service, U. S. Department of Agriculture.



CENTERLINE SECTION
Fig. 1 Typical baffle structure for pipe outlet

Similitude Relationships. For convenience in applying laboratory results to field installations, all dimensions are expressed in terms of the diameter of the pipe. Thus, if the structure width is 6.0 ft and pipe diameter is 1.0 ft, the width is 6.0 pipe diameters and width ratio is 6.0. Therefore, two structures are geometrically similar when their corresponding dimensions, expressed in pipe diameters, are the same. Dynamic similarity obtains when the ratio of the inertia forces to the gravity forces in one structure is the same as in the other. As can be shown* readily, this force ratio, F_0, for the pipe outlet structure is given by the dimensionless ratio

$$F_0 = \frac{V_0^2}{gD_0} = \frac{Q_0^2}{\frac{\pi^2 D_0^5 g}{16}} \qquad [1]$$

where V_0 is the velocity in the pipe, g is the acceleration of gravity and D_0 is the pipe diameter. When F_0 has the same value for two geometrically similar structures, dynamic similarity, and therefore complete similarity, will obtain and the flow patterns will be similar.

The ratio, F_0, incidentally, is twice the velocity head of the flow in the pipe divided by the pipe diameter. When such ratios contain the gravity term, g, they are usually called Froude Numbers. However, in this case the ratio is calculated for the closed portion of the system, where the gravity forces have no influence and there is some question regarding the appropriateness of the use of the term, Froude Number. For this reason, and to avoid possible confusion in the use of terms, the ratio, F_0, is called the "velocity head factor."

The use of similarity laws reduces the independent variables to two: (a) F_0, which expresses dynamic similarity, and (b) W/D_0, the width ratio, which expresses geometric similarity. The dependent variables are the back pressure ratio, h_0/D_0, and the various dimensionless ratios expressing the proportions of the structure.

Having established similarity laws, hydraulic model tests were made in which F_0 and W/D_0 were kept constant and the dimensions of the baffle box were varied until satisfactory flow conditions were obtained. This gave one structure which can be fitted to any number of field conditions as long as the values of F_0 and W/D_0 remain the same. The structure is fitted to the field conditions by changing the scale which is equivalent to changing the diameter of the pipe.

Range of Tests. Experiments were conducted over ranges wide enough to include all conditions likely to be encountered in the field. In the studies W/D_0 ranged from 2.0 to 9.5 and F_0 ranged from 1 to 190. The diameter of the pipe used in the models ranged from ¾ to 3 in. The other dimensions of the structure were also varied through wide ranges in order to obtain the combination that gave the best over-all result.

APPARATUS AND PROCEDURE

Most of the experiments were carried out in the special flume shown at the right in Fig. 2. This flume is 7 ft long, 4 in wide, with sidewalls about 2 ft high. The near sidewall in the figure contains a large glass window on the face of which is a grid of vertical and horizontal wires spaced at intervals of 0.5 and 0.2 ft, respectively. The window and the grid made possible convenient photographic and visual observation of the flow patterns occurring in the models.

The flow into the model was provided by the portable constant-head water

*R. L. Daugherty, "Hydraulics," p. 108, McGraw-Hill, New York, 1937.

supply unit shown at the left in Fig. 2. The rate of flow was measured with a venturi meter in the supply unit and regulated by valves. The pipe entered the flume at the lower right corner of the window. By changing the size of the "pipe", actually a hole in a block, the width ratio, W/D_0, could be varied. Further variation in the width ratio was accomplished by using a half model with the window in the plane of symmetry. Baffles and caps could be installed easily and quickly in the flume, and the length L_1, of the baffle box could be varied at will. By this convenient means, all the necessary combinations of baffle-box dimensions and width ratios could be represented in a relatively short time.

Flow conditions for each model were studied by observing the motion of entrained air and by probing with a short thread tied to a thin rod. Pencil sketches were drawn for each test condition showing the baffle-box dimension, the back pressure at the pipe outlet, the outline of the flow, and the flow pattern in the box. Notes on each sketch described the general quality of the flow such as steadiness, entrained air, uniformity, etc. Photographs of each test flow furnished a valuable record of performance of the model.

In order to check the results obtained with the small models, tests were made with models having width ratios of 3, 6, and 9, and a pipe diameter of 3 in. These larger scale experiments gave more reliable information on air entrainment, steadiness of flow, ventilation of the overfall, and the adequacy of the stilling pool. By observing these models, information was also obtained on the proper heights of headwall and sidewalls required for safe freeboard. A study also was made to determine the effectiveness of the drains through the baffle on preventing sediment from depositing in the box and clogging the pipe during low flows.

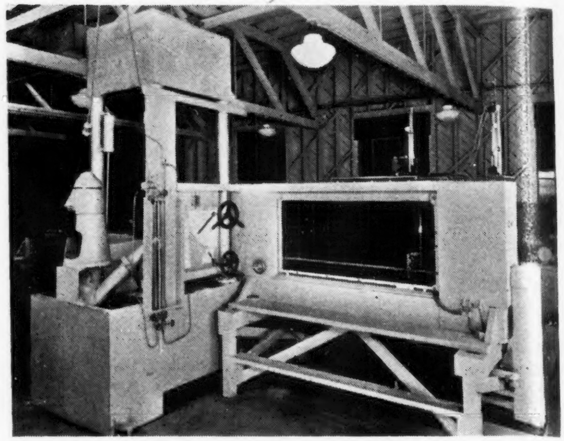


Fig. 2 Flume in which experiments were conducted for the development of a baffle type energy dissipator

PERFORMANCE OF THE STRUCTURE

Criteria for Satisfactory Performance. The performance of a structure may be evaluated by measuring its ability to dissipate energy. However, this is only one of many practical requirements which must be met and therefore it was necessary to choose other means of judging performance. After studying the problem in the laboratory, criteria were adopted for selecting those structures which were satisfactory. Listed in the order of their importance, these criteria are:

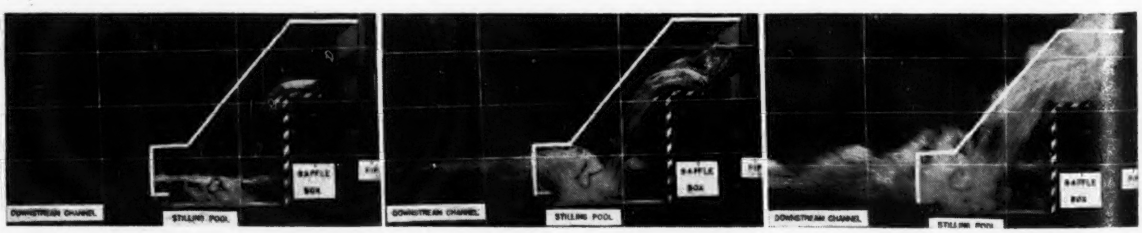
1 Steadiness of flow whatever the pattern
2 Sufficient energy dissipation to give outflow conditions that will not produce excessive erosion at the structure, or downstream therefrom
3 Minimum air entrainment
4 Uniform distribution of the flow discharging over the baffle
5 Minimum splashing beyond the limits of the structure
6 Minimum structure sizes
7 Minimum back pressure consistent with the preceding factors
8 Proper balance between the above factors to achieve a practical design.

Regimes of Flow. For convenience in selecting the desirable structures, the various performances obtained were classified into three types according to the general acceptability of the flow pattern in the light of the established criteria. The pattern resulting from relatively low discharges, which was called Type I flow, gave good performance but resulted in uneconomical structures. Type II flow occurred at much higher discharges, but the flow remained steady and evenly distributed, thus giving good performance with a relatively smaller and more economical structure. As the discharge is increased further, the water rises higher along the headwall, becomes unsteady, and may cascade directly into the stilling pool, without coming in contact with the cap. This unsatisfactory condition was described as Type III flow.

A flow of one type can be changed to either of the other two by changing the dimensions of the baffle box, as well as by changing the flow. Fig. 3 shows that by varying the discharge only, all three types may be obtained in a model designed to meet all of the requirements for performance and economy. The most economical structure that gave Type II, Fig. 3(b), for design discharge was the one selected. Type I flow in Fig. 3(a) is at one-half the design discharge and Type III in Fig. 3(c) occurs at 1.7 times the design flow. As Fig. 3(c) shows, the Type III flow tends to fall clear of the cap and entrains considerable air, thus producing an undesirable condition.

Attention is called to the mean values of the back pressure, h_0, shown below each of the views in Fig. 3. They also show the end of the pipe in the headwall.

Although in Fig. 3 the flow patterns above the baffle box are very different, the patterns in the box are alike. Gravity forces do not exist in the baffle box because any filament of flow in the box is buoyed up with a force equal to its own weight since it is submerged in a fluid of like density. This becomes clear when it is realized that a fluid within a fluid, just as a solid submerged in a fluid, is buoyed up by the weight of fluid displaced. Under these conditions, the filament will neither tend to rise nor sink, and hence the force of gravity is cancelled out. Therefore, the pattern is determined practically entirely by the geometry of the system. Since the geometry does not change, the flow pattern can be expected to remain fixed regardless of the rate of flow. On the other hand, above the baffle box where a free surface exists, the gravity forces are obviously important and in this region the pattern is determined by the simultaneous action of the inertia and gravity forces. The pattern will vary as the ratio of these forces varies and since this ratio is expressed by the parameter, F_0, this is equivalent to saying that the flow pattern above the baffle box is dependent on the velocity head factor. That this is true is shown in Fig. 3.



(a) Low flow, $F_0 = 8$; $h_0 = 4.2D_0$ Type I Flow — Underload Discharge

(b) Design discharge, $F_0 = 32$; $h_0 = 5.6D_0$ Type II Flow — Recommended Performance

(c) High discharge, $F_0 = 96$; $h_0 = 8.0D_0$ Type III Flow — Overload Condition

Fig. 3 Effect of discharge on flow conditions. All structures are identical. Only the discharge (velocity head factor, F_0) is varied. $D_0 = 0.078$ ft; $W/D_0 = 4.3$; $p_0 = 0.3D_0$; $L_1 = 3.2D_0$; $h_1 = 2.8D_0$; $x_1 = 1.4D_0$; $p_2 = 0.53D_0$; $L_2 = 5.2D_0$

GLOSSARY OF TERMS

b = distance from sidewalls to centerline of longitudinal sills in stilling pool, ft
b_1 = width of drain opening, ft
$C = \left(\frac{\pi}{4} \times \frac{D_0}{W}\right)^{2/3}$ = a critical depth coefficient
C_c = exterior chamfer of baffle, ft
C_f = fillet at corner formed by cap and baffle, ft
C_L = stilling pool apron length coefficient
C_E = Coefficient of energy loss
D_0 = Diameter of pipe outlet, ft
$d_c = \sqrt[3]{Q_0^2/W^2g}$ = critical depth, ft
E = a specific energy, ft-lb per lb
ΔE = loss of energy, ft-lb per lb
f friction factor for pipes
$F_0 = V_0^2/gD_0$ = velocity head factor
g gravitational acceleration, ft/sec²
H = net drop from baffle crest to stream bed, ft
h_e = entrance head loss, ft
h_f = friction head loss, ft
h_L = total losses in pipe leading to structure, ft
h_2 = height of end wall, ft
h_1 = height of head wall, ft
h = back pressure head on pipe outlet, ft
$h_v = V_0^2/2g$ = velocity head of flow in pipe, ft
h_0 = net height of baffle, ft
K = coefficient in back pressure equation
K_e = loss coefficient for entrance
K_f = loss coefficient for pipe friction
K_m = loss coefficient for miscellaneous causes
L_1 = length of baffle box, ft
L'_1 = top length of side wall, ft
L_2 = length of stilling pool, ft
L'_2 = horizontal sidewall dimension for stilling pool, ft
L_s = overall length of structure, ft
l = length of pipe carrying discharge to structure, ft
p_0 = drop in floor of baffle box below pipe invert, ft
p_1 = drop of stilling pool floor below pipe invert, ft
p_2 = depth of stilling pool (height of transverse or end sill)
Q_0 = design discharge, cfs
Q_1 = discharge through baffle drains, cfs
t_1 = thickness of baffle, in
$V_c = \sqrt{d_c g}$ = critical velocity, ft/sec
V_0 = velocity of flow at pipe outlet, ft/sec
V_2 = velocity of flow discharging from baffle box, ft/sec
V_3 = velocity in downstream channel, ft/sec
W = width of structure, ft
x_1 = overhang of baffle cap, ft
y_1 = thickness of cap, ft
θ = slope of inlet pipe, deg

Fig. 4 indicates diagrammatically the pattern for a typical case of Type II flow. The flow in the plane of projection is indicated by lines with arrows. Flow normal to this plane is represented by dots and crosses which indicate movement towards and away from the observer, respectively. The center-line section shows the high velocity jet issuing from the pipe outlet, striking the baffle, being deflected upward and then being turned horizontally upstream by the cap. This action produces a roller with a horizontal axis above the pipe and below the cap. Upon reaching the headwall the flow is deflected upward again and rises along the headwall to a height determined by its velocity, whereupon the flow must cascade over the incoming flow, the crest of the baffle, and thence into the stilling pool. As is shown both in the center-line section and in section 1-1, a roller extending across the structure occurs at the upstream face of the cap and under the fall. Section B-B of Fig. 4, which is a plan view taken approximately through the center of the baffle box, shows that the jet also is deflected sideways by the baffle, causing a roller with vertical axis to form on each side of the pipe.

The tortuous path that the flow is forced to take in passing through the structure results in the formation of much turbulence, and hence in high energy dissipation. The energy line for a typical structure operating at design discharge is shown in Fig. 5. This shows that 86 per cent of the total energy existing at the pipe outlet is dissipated by passing the flow through the structure. By far the greater portion of the dissipation occurs in the baffle box although an appreciable amount also occurs in the stilling pool. Fig. 5 also shows the flow over the end sill. This sill deflects the main flow upwards away from the stream bed causing a roller to form at the bed. As may be seen, the direction of flow at the bed under the roller is actually upstream. This tends to move bed material toward the sill and protects the structure against undermining.

Effect of Baffle-Box Dimensions on Flow. In the course of determining the proper size of baffle box, it became necessary to study the effect on flow conditions caused by varying the dimensions of the box. This study yielded not only the proper sizes to use but also furnished some rational basis for these sizes. Flow conditions with baffle boxes that are too short and too long are illustrated in Fig. 6(b) and (c), respectively, and flow with design condition is shown in Figs. 3(b) and 6(a). It will be noted that with the short box the back pressure was high and that the flow rose high up along the headwall and appeared to be of Type III. This was due mainly to the throttling of the flow as it passed through the small gap between the cap and headwall. With the long box shown in Fig. 6(c), the back pressure was reduced slightly and the flow was a little quieter than for the shorter and more economical structure shown in Fig. 6(a).

Fig. 6(d) and (e) show the flow patterns with the baffle too low and too high. The low wall causes a very disturbed and unsteady flow pattern that is unsatisfactory. This results because there is not enough space between the floor and the cap to permit the jet from the pipe to hit the baffle and be turned back towards the headwall as in the standard flow pattern shown in Fig. 4. The result is that the entire pipe jet is deflected sideways by the baffle, forming two strong vortices with vertical axes which entrain considerable air and produce an unsteady, non-uniform flow distribution. When the baffle is made too high, as in Fig. 6(e) flow is very

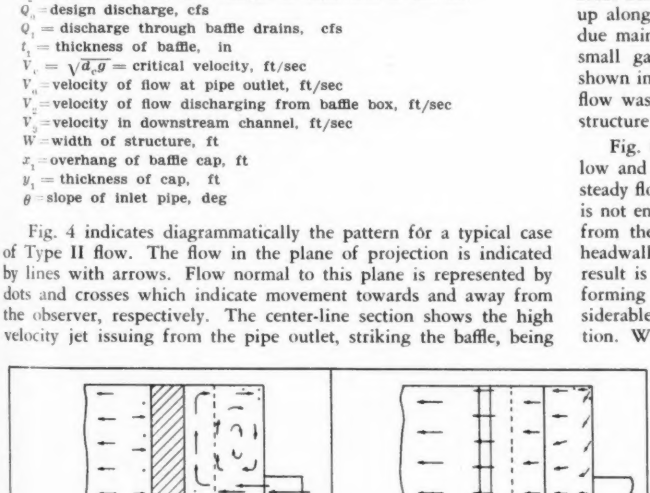


Fig. 4 Sketches of the flow pattern of recommended performance — Type II flow
$F_0 = 32$; $W/D_0 = 6.7$; $L_1 = 2.5D_0$; $h_1 = 2.0D_0$; $x_1 = 1.0D_0$

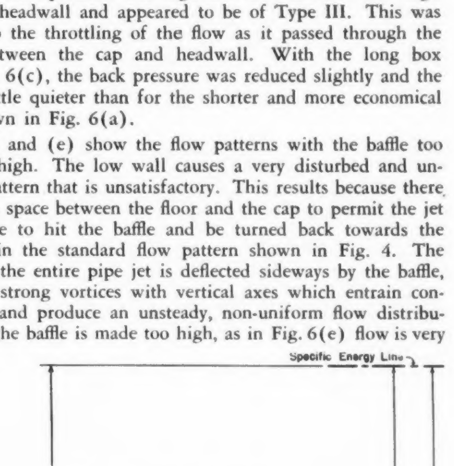


Fig. 5 Typical pipe outlet structure showing energy line
$W/D_0 = 5$; $p_0 = 0.3D_0$; $L_1 = 2.5D_0$; $h_1 = 2.0D_0$; $x_1 = 1.0D_0$; $L_2 = 5.0D_0$; $p_2 = 0.4D_0$; $d_c = 0.8D_0$; $F_0 = 16$; $h_v = 8.0D_0$; $h_0 = 4.7D_0$

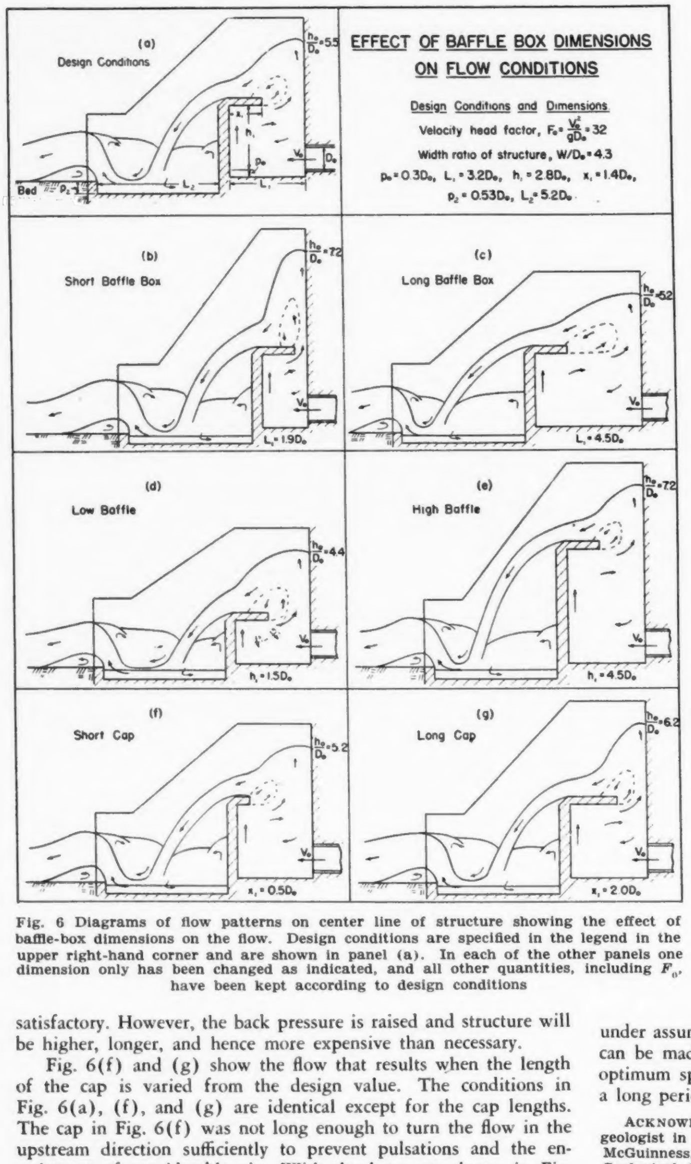


Fig. 6 Diagrams of flow patterns on center line of structure showing the effect of baffle-box dimensions on the flow. Design conditions are specified in the legend in the upper right-hand corner and are shown in panel (a). In each of the other panels one dimension only has been changed as indicated, and all other quantities, including F_0, have been kept according to design conditions

satisfactory. However, the back pressure is raised and structure will be higher, longer, and hence more expensive than necessary.

Fig. 6(f) and (g) show the flow that results when the length of the cap is varied from the design value. The conditions in Fig. 6(a), (f), and (g) are identical except for the cap lengths. The cap in Fig. 6(f) was not long enough to turn the flow in the upstream direction sufficiently to prevent pulsations and the entrainment of considerable air. With the long cap shown in Fig. 6(g), the gap between the cap and headwall constricted the flow, and by causing it to rise higher along the headwall, increased the back pressure. This performance was good, but no better than that of the smaller structure of Fig. 6(a).

In Fig. 6 the floor drop, P_0, i.e., the distance from the invert of the pipe to the floor, was $0.3D_0$, since for this case tests showed that this gave approximately the optimum condition. The drop makes it possible for the flow to spread downward as well as upward. Consequently when the baffle is reached the velocity is less than without the drop and the resulting flow is quieter. Increasing this drop by severalfold caused no further improvement and is, therefore, uneconomical. The drop in the floor simplifies the construction slightly and provides better protection against clogging the box with debris deposited by the flow.

Experiments in which the slope of the pipe, θ, was varied showed that the flow was improved by inclining the pipe. This is because the flow which is now directed slightly downward strikes the floor and is spread further before it reaches the baffle, thus producing a more favorable flow condition at the baffle. Experiments with fillets of various sizes under the baffle cap showed that they had practically no effect on the performance as long as they were of reasonable size.

(Concluded in the September issue)

Weed Control with Chemicals

(Continued from page 298)

Being in common use in agriculture for a number of years, it is also known as a contact killer and soil sterilant. At 1 lb per sq rd contact kills have been satisfactory but larger quantities are needed for appreciable sterilizing effects.

Time of application has been important in securing best results. Applications between June 15 and July 15, after weeds have germinated and made some growth, have been more satisfactory.

The use of chemicals for weed control will probably increase because of the desire and necessity of doing a better job of control, the introduction of new weed-killing chemicals, and the interest in labor-saving methods.

The agricultural engineer is the person to whom we look for the development, manufacture, servicing, and distribution of such machinery. The up-to-date farm of tomorrow may have as a part of its regular equipment some sort of chemical weed control equipment. There is a possibility that there may be a more widespread use of community equipment for the spraying or distribution of chemicals for this purpose. There is currently a trend developing in the direction of weed control in cultivated crops by these methods. Perhaps such tools can be regular equipment for tractors, or adapted from such tools as potato sprayers, etc. With the trend toward the mechanization of all farm operations and raising the working standards of the farmer, the scythe may hang in the tree more of the time in the future.

Water Transmissibility and Storage Coefficients

(Continued from page 300)

been given, and three examples of the application of such coefficients have been discussed. The coefficients have been used to determine the source of water supply, the quantity to be expected from each source, and the minimum yield to be expected from a well field under assumed conditions of operation. Additional applications that can be made with the knowledge of these coefficients include the optimum spacing of wells and the prediction of water levels over a long period of time to prevent obsolescence of equipment.

ACKNOWLEDGMENTS: The criticism and assistance of O. E. Meinzer, geologist in charge of the division of ground water, L. K. Wenzel, C. L. McGuinness, and R. M. Jeffords of the division of ground water, U. S. Geological Survey, and Kyle Engler of the Arkansas Agricultural Experiment Station are gratefully acknowledged.

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Techniques Used in Raindrop Erosion Studies and Practical Applications of Data

By W. D. Ellison
MEMBER A.S.A.E.

IN THE studies reported by the author in the paper, entitled "Studies in Raindrop Erosion," appearing in AGRICULTURAL ENGINEERING for April and May, 1944, the techniques employed and the instruments used may be said to represent a first "try", and considerable attention should be given to improving them before they are adopted as standard for research work. It may be well to point out some of their weaknesses and to enumerate some of the considerations which led to the development of the splash intercepters.

It seems that the samples collected by these low splash plates will not represent a true cross section of all the splash, but that they will contain an unduly large portion of the splash closest to the soil surface. Here are some of the reasons for constructing this low splash board: First, in comparison with higher plates it reduced the effects of wind whipping across its surface. Wind effects on higher plates would remove much of the soil before it could move down the plate and be deposited in the retaining pan below. A second reason for the low plates was to reduce the number of raindrops striking it. Each raindrop striking the plate from an angle, as when driven by wind, would tend to splash the soil off. A third reason for using low splash plates is that they will not shield as much of the soil surface to the leeward, during driving rainstorms, as would higher plates.

In addition to considering different heights of splash plates, the author considered using an intercepter with no splash plate at all. It would consist only of a small tank set in the ground. With this type of installation the splash would fall in from the top. Decision not to use this type of instrument was based on the fact that it would not permit separating the uphill from the downhill splash, and neither would it permit the separation of splash on the leeward from that on the windward for purposes of studying the effects of wind on soil transportation.

In reference to the low splash plate, which was finally selected, it is believed that it should be calibrated and samples referred to the calibration curves before more thorough analyses can be made. Some preliminary studies indicated that most of the gravel and sand as well as the larger aggregates were carried by the splash near the surface, and that the smaller particles were carried by the higher splashes. Since these samplers may contain unduly large portions of the splash nearest the surface, the data relating to particle sizes and aggregates carried by the splash were not treated mathematically in this paper. Such analyses will have to await calibrations.

It is possible that, after calibration curves are developed, modifications will need to be made in the formula which shows the relationship of soil splash to velocity and size of drops and the intensity of rainfall. It is the author's belief, however, that any such modification will be very slight and probably insignificant.

Since completing these experiments it has occurred to the author that a better type of spash sampler may be developed by using a piece of pipe, say, about 4 in in diameter, for a retention tank, and using four 90-deg angles for the splash plates. Each leg of the angular splash plate would be about 2 in; these could be made of sheet metal and any other flexible materials available.

Perhaps combinations of the above samplers will prove advantageous, and probably even new instruments and new techniques not yet employed can be developed. This study of raindrop erosion has involved a new procedure, employing new instruments and new techniques, and before standards are adopted considerably more thought should be given to objectives, instruments, and methods.

Practical Applications of Data. These raindrop erosion studies seem to show that most of the erosional damage on the slopes above the rills and gullies are caused primarily by impact of raindrops. The four principal groups of factors affecting this erosion are (1) characteristics of the soil, (2) characteristics of the cover, (3) characteristics of the slope, and (4) characteristics of the storm.

1 *The Soil.* Some soils are more stable under rainfall than others. Splash erosion studies on the different soils should enable us to assign values to different soils, which will express their relative stability or their resistance to raindrop erosion. Such results should be most helpful in making land-use plans. For example, a soil that suffers high rates of splash erosion should not be plowed clean as often as a more stable soil, one not so easily damaged by raindrops, even though it be on a lesser slope than the more stable soil. This has been recognized for some time, but there has been no numerical evaluation to use as a guide, and raindrop erosion studies should enable making such evaluations.

2 *Soil Covers.* Cover crops and mulches which protect the soils against raindrop impact have a pronounced effect in preventing erosion. Installation of splash intercepters in different crops and where different residue disposal practices are employed would afford a means of evaluating the primary effects of these soil covers on splash erosion. Such determinations should be applicable in all soil and water conservation work.

3 *Slope.* While the gross slope has an effect on raindrop erosion, it is believed its over-all effects can be modified considerably by tillage practices. For example, ridges on the contour may cause raindrops falling on their uphill sides to throw most of the splash in upslope directions. On the other hand, the slope on the downhill sides of the ridges may increase the downslope splash. Ridges, clods, and other surface irregularities will also delay the formation of a connecting film of water which will cover the entire soil surface. This would considerably delay splash erosion, and it may considerably reduce the splash on fields, especially during storms of low intensity or short duration. Installation of samplers on fields where different tillage practices are used should be very helpful in evaluating the effects of surface conditions as developed and maintained by these practices.

4 *The Storm.* Since the variables of raindrop size and velocity have such great influence on erosion, it seems important that ways be developed for measuring size and velocity of raindrops before much more progress can be made in comparing and studying the effects of one storm with another. It is the author's belief that such detailed studies of rainfall coupled with studies of splash erosion will lead to improvements in the use of experimental data.

Studies of splash erosion should not be considered as a substitute for measuring soil loss. Rather it offers a means of making more detailed analysis of soil loss data. For example, large amounts of soil lost from a watershed may be caused by high rates of raindrop erosion, high rates of rill and gully erosion, or by both. Gully erosion may cause different types of damage than does raindrop erosion, and the corrective measures required to control a gully may be different than those required to control the raindrop splash. Splash erosion will cause topsoil to be displaced on the entire surface of a hillside, while gullies and rills do this only in advanced stages of erosion, or during most severe and unusual storms.

In addition to producing different types of erosional damage, each type of erosion will have different effects on the hydrology of the land. Gully erosion may have only slight effects on infiltration over the entire surface of the land, while splash erosion may seal the soil surface and retard infiltration rates on the entire field. Because of these and other reasons, the author believes that studies of splash erosion are going to be most helpful in experimental hydrologic studies relating to soil and water conservation and floods.

This is part of the discussion of the author's paper, published in AGRICULTURAL ENGINEERING for April and May, 1944, presented before the Soil and Water Division at the annual meeting of the American Society of Agricultural Engineers at Milwaukee, Wis., June, 1944.

W. D. ELLISON is hydraulic engineer, division of water conservation and drainage (research), Soil Conservation Service, U. S. Department of Agriculture.

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Electrocution by Electric Fence Controller

By Charles F. Dalziel

THE following description of the electrocution of George Boles was constructed from information obtained by me on May 9, 1944. The accident occurred on R. L. Friend's ranch, located about one-half mile west of Cook's Camp on Highway 99, between Tipton and Pixley, Tulare County, California, at approximately 2:00 p.m. on April 30, 1944. At the time the accident occurred the weather was hot, clear and calm.

Mr. Friend had pumped his irrigation reservoir full and left the ranch before a group of neighborhood children entered the premises to go swimming. One of the boys, George Boles, dressed only in homemade overalls and dripping wet, was standing on the 8-in steel pump discharge pipe lying in the earth bank of the reservoir when he grasped a barbed electric fence wire energized from an a-c intermittent electric fence controller. The electric fence was about 30 in above the ground and ran along the earth bank of the reservoir about a foot away from the high water line. The discharge pipe and the wire were at right angles. The water level in the reservoir was only a few inches below the bottom of the discharge pipe. The shock caused the boy to lose his balance and he slipped off the pipe into the water but could not release himself from the electric fence. Upon return to his home Mr. Friend was attracted by the children calling for help. He rushed to the reservoir and found the boy suspended by the wire firmly clamped between his left arm and chest at the armpit and his feet dangling in the water below. He promptly rescued the boy, put him in his automobile, and drove to Cook's Camp for aid. The boy gasped a few times at Cook's Camp, but was pronounced dead upon arrival of a physician.

The time of contact with the electric fence is not known. However, since the children were still calling for help when Mr. Friend returned and none had left the reservoir to seek aid, which was at Cook's Camp (the boy's home) only a half-mile distant, it is probable that the time of contact with the fence was only a matter of a few minutes.

Officials from the electric utility made extensive investigations and voltage tests on May 2 and 4, and found no reason to question the installation with regard to defective wiring or equipment. The controller had been disconnected for a day or so after the accident but had been replaced in service several days before I visited the scene. The controller was installed inside a dry barn and was apparently operating normally. Careful inspection of the premises was made with regard to the electrical installation. The pump was running and voltage measurements indicated normal conditions. As a final check, I carefully touched the fence at the spot where a small piece of the boy's overalls had been left on one of the barbs to mark the exact location of the accident.

George Boles was born on May 4, 1937, and at the time of the accident he was nearly seven years old. Estimated weight was 40 pounds; estimated height 3 ft 7 in. His father Jeane came from Arkansas and his mother Veria came from Texas. Last fall he received treatment at the Tulare County Hospital for a severe burn on his groin. He suffered from recurrent upper respiratory infections and had enlarged tonsils which were about to be removed. The two physicians who examined him stated that he was of slender build but normal in every respect. The hospital record stated that heart sounds, lungs and abdomen were normal. The mortician said he had a normal thymus gland and no bruises or other marks were found on his body which might have been the result of his accident. The coroner stated that since the cause of death was certain, no autopsy was made.

I took the electric fence controller with me and the following are the results of tests made in the electrical laboratories of the department of electrical engineering, at the University of California, Berkeley, May 11, 1944:

This controller is the intermittent a-c type, and carries the Underwriters' Laboratories seal, "Listed under re-examination service."

Interval between shocks: 1.20 sec. (Determined before removal from Mr. Friend's ranch and at the laboratory.)

Shock duration: $3\frac{1}{2}$ to $4\frac{1}{2}$ cycles.

Shock intensity: Input held constant at 120 v 60 cycles.

Selector switch position	Short-circuit milliamperes rms (Instrument resistance, 557 ohms)	Open-circuit volts rms (Measured with electrostatic voltmeter)
Short test	18.7	1200
Normal	42.0	400
Dry*	25.3	825
Very dry	18.7	1200
Training	42.0	400

*Operating position

Insulation test: 110-v terminals to high-voltage terminal and case measured 100 plus megohms. (Measured with 500-v Megger)

Interrupter cut-off test: Interrupter was short circuited and thermal cut-out tripped out satisfactorily.

Remarks: All internal connections were tight; construction was rugged and carefully assembled. There was no evidence of moisture, repairs or tampering.

Conclusions: In view of the information obtained regarding this accident and tests upon the unit involved, it is concluded that a seven-year-old boy was electrocuted as a result of a contact with an electric fence energized from an a-c 60-cycle intermittent electric fence controller in which the current was limited to 25 rms milliamperes with the duration of each shock ranging from approximately 0.055 to 0.075 sec and a period between shocks of 1.20 sec. It is also concluded that although the shock intensity was well below the value believed to be dangerous for children for one single shock of approximately five cycles duration, a very dangerous and torturous hazard is created in those instances in which a victim cannot release himself from contact and is subject to repeated or intermittent shocks, if even for only a relatively few minutes.

It should be mentioned that, although numerous fatalities have been attributed to contact with electric fences, almost without exception these fatalities have occurred on wires energized directly from 120-v lighting circuits or homemade devices. The case cited above and the Toppenish accident (see references appended to this paper) are the only recorded fatalities caused from electric fences energized from "approved"* electric fence controllers. It may be significant that both of these fatalities were caused from a-c intermittent electric fence controllers. This investigation is believed to have special significance, as death was apparently caused by a current of only 25 milliamperes, which to date is the smallest current substantiated as causing human electrocution in this country.

The personal hazard of homemade electric fence controllers must be emphasized. When informed people have the opportunity, it is their duty to warn farmers of the danger resulting from the use of unauthorized devices. The conditions of wet contact such as existed in this case greatly increase the hazard; however, such conditions are of common occurrence in actual field installations. The regulatory agencies charged with issuing "approvals" are cognizant of these extreme conditions and safety regulations are based on conservative minimum values of body impedance designed to simulate conditions of wet contact.

*"Approved" means approved, labeled or listed as conforming to the standards of the Industrial Commission of Wisconsin, the Underwriters' Laboratories Inc., the National Bureau of Standards, or other institutions of recognized standing.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

CHARLES F. DALZIEL is associate professor of electrical engineering, University of California, Berkeley.

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NEWS SECTION

Nominations for A.S.A.E. 1945 Medal Awards

IN accord with the rules governing the award of the John Deere and Cyrus Hall McCormick gold medals, the Jury of Awards of the American Society of Agricultural Engineers will receive from members of the Society, up to November 1, nominations of candidates for these two awards for the next year.

Members of the Society who nominate candidates for either award are requested to keep in mind the purposes of each medal and formulate their nominations accordingly. The John Deere medal is awarded for "distinguished achievement in the application of science and art to the soil," which citation is interpreted to cover more than a mechanistic concept of engineering, and to include chemistry, physics, biology, and any other science and art involving the soil, the "application" being acceptable to "evaluation by the engineering criteria of practicality and economic advantage."

The Cyrus Hall McCormick medal is awarded "for exceptional and meritorius achievements of a continuing career or to any single item of engineering achievement, and to apply equally to all special fields and types of engineering in agriculture."

The Jury of Awards desires that members of the Society consider it their duty and obligation to give serious thought to the matter and nominate for either or each of these awards the men they believe to be most worthy of the honor. Each nomination must be accompanied by a statement of the reasons for nominating the candidate and the qualifications of the nominee, including his training, experience, contributions to the field of agriculture, a bibliagraphy of his published writings, and any further information which might be useful to the Jury in its deliberations.

The Jury will accept and consider nominations received on or before November 1, and these nominations should be addressed directly to the Secretary of the Society at Saint Joseph, Michigan. The Secretary will supply on request a standard set of instructions for preparing information in support of nominees for the Society's gold medal awards; it is important that these instructions be followed in preparing material on behalf of any nominee.

Kaiser Heads P.C.A. Farm Bureau

THE Portland Cement Association announces that W. G. Kaiser, a past-president of the American Society of Agricultural Engineers, will head the Association's new farm bureau.

Mr. Kaiser joined the P.C.A. staff at Chicago in 1917 as an agricultural engineering specialist in farm construction, and since 1933 has been manager of its cement products bureau. The vital importance of saving labor and improving the fire safety and sanitation of farms has been emphasized by the war, and the establishment of its farm bureau will enable the Association to render greater service to various farm agencies and rural contractors in solving problems encountered in designing and building farm facilities of concrete.

H. P. Smith on Engineering Library Staff

THE Texas National Resources Foundation, with headquarters in San Antonio, three years ago established a free public library to accumulate material for the conservation and development of the natural resources of the state of Texas, much of which includes a great amount of data useful to engineers. The American Society of Agricultural Engineers has been invited to designate a liaison representative on the board of advisory trustees for this library, and A.S.A.E. President R. H. Driftmier has accordingly appointed H. P. Smith, chief of the agricultural engineering division, Texas Agricultural Experiment Station, as the Society's representative. It is proposed to expand the facilities of the library to cover adequately all phases of engineering endeavor and to have the library serve as an outstanding institution in aiding the conservation and development of the natural resources of the state.

North Atlantic Section Meeting

THE annual meeting of the North Atlantic Section of the American Society of Agricultural Engineers will be held at the Commodore Hotel in New York City, September 26 and 27, according to announcement of the Section officers. A most attractive program is being arranged, and all Society members, in all parts of the country, as well as other interested persons, are cordially invited to attend.

A.S.A.E. Meetings Calendar

September 26 and 27 — North Atlantic Section, Commodore Hotel, New York.

December 11 to 13 — Fall Meeting, Stevens Hotel, Chicago.

Personals of A.S.A.E. Members

Wallace Ashby, principal agricultural engineer, and *T. A. H. Miller,* senior agricultural engineer, division of agricultural engineering, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture, are two of the authors of Circular No. 701, entitled "Hog-Housing Requirements," recently issued by the Department.

Leonard A. Brandrup is now engaged as agricultural engineer by Seabrook Farms, a 15,000-acre vegetable farm project in southern New Jersey. He was previously service manager for New Idea, Inc., at Sandwich, Ill.

Everett H. Davis recently resigned as associate engineer of REA and is now employed as irrigation engineer, division of irrigation, U. S. Soil Conservation Service, with headquarters at Colorado State College, Fort Collins.

W. D. Ellison has been transferred from his duties as project supervisor of the watershed and hydraulic studies at Coshocton, Ohio, to become assistant chief of the division of drainage and water control, Soil Conservation Service, U. S. Department of Agriculture, Washington.

L. W. Garver who has been serving more recently in the capacity of supervisor of inventory control and priorities of the Massey-Harris Co., at the home office of the American company in Racine, Wis., has just been appointed branch manager for the company's Columbus, Ohio, branch, which has charge of the distribution of Massey-Harris products throughout the states of Ohio, Indiana, the lower peninsula of Michigan, and western Pennsylvania. Mr. Garver is returning to Columbus where he first joined the Massey-Harris organization approximately fifteen years ago.

Andrew Hustrulid, assistant professor of agricultural engineering, University of Minnesota, is one of the authors of extension bulletin No. 244 just issued by that institution, entitled "Freezing Foods for Home Use."

George W. Kable, editor of "Electricity on the Farm," is author of an article, entitled "Needed: Farm Electric Dealership," which appeared in the June 30 issue of "Printers' Ink." Mr. Kable, a past-president of A.S.A.E., was formerly director of the Oregon C.R.E.A., director of the National Rural Electric Project and of the research activities of the National C.R.E.A., consultant on rural electrification to the USDA, and head of the agricultural engineering development division of TVA.

S. W. McBirney, who more recently has been serving as chief, field and construction machinery section, War Food Administration, has been transferred back to the Division of Agricultural Engineering, Bureau of Plant Industry, Soils, and Agricultural Engineering, USDA, with which he was formerly connected. The Bureau is reopening its sugar beet machinery development project, which will be cooperative with both Colorado State College and Michigan State College. Mr. McBirney will head up this project and will be stationed at Fort Collins, Colo.

Howard Matson, who for some time has held the position of chief of the regional engineering division (Region 4) of the Soil Conservation Service, was recently made chief of the newly created Regional Water Conservation Division of the SCS. His headquarters will continue to be at Fort Worth, Texas.

W. J. Nemerever who was for a time employed as assistant in the mathematics department of Ohio State University, is now in the employ of the Boeing Aircraft Company at Seattle, Wash.

F. W. Peikert recently resigned as professor of agricultural engineering at the A. & M. College of Texas, and is now connected with the development department of the Goodyear Tire and Rubber Co., in Akron, and is working on farm tractor and implement tires.

(News continued)

Personals of A.S.A.E. Members *(Continued)*

Albert F. Keegan, who more recently has been engaged as junior mechanical engineer with Walter D. Teague, a firm of industrial engineers of New York City, will, on September 1st, take up work at the Dwight Indian School at Vian, Okla., as a member of the faculty. He will be the engineer on the staff and his duties will include agricultural mechanics, farm construction, plumbing, electricity, maintenance of the buildings and landscaping of the school grounds. The school is conducted by the Board of National Missions of the Presbyterian Church of America. A farm of 40 acres is attached to the school and is used to teach Indian boys modern agricultural practices.

J. B. Kelley, professor of agricultural engineering at the University of Kentucky, is one of the authors of Circular 38 recently issued by the extension division of that institution, entitled "Storing Foods in Freezer Lockers," which contains suggestions for preparation, packing, freezing, thawing, and cooking. The agricultural engineering staff of the university was also responsible for Circular 397 recently issued, and entitled "Farm Building Plans," which is a catalog of plans for farm buildings and equipment suitable for use in Kentucky.

R. Earl Storie, associate soil technologist, University of California, is on six months leave from his duties where he is in charge of soil survey, and is located at Bogota, Colombia, where he is demonstrating the methods of soil surveys and land classifications used in this country. The work is under the auspices of the department of international relations of the Office of Latin-American Agriculture.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

J. C. Cahill, district co-ordinator, Detroit Edison Company, 2000 Second Avenue, Detroit, Mich.

Don Cook, assistant sales manager, Columbian Steel Tank Co., 1509 West 12th Street, Kansas City 7, Mo.

John W. Crowell, draftsman, North American Aviation, Inc. (Mail) 421 Cimarron, Grand Prairie, Tex.

L. O. Drew, instructor in agricultural engineering, Clemson Agricultural College, Clemson, S. C. (Mail) Box 1134.

Harold F. Mayer, advertising and sales promotion manager, Certain-teed Products Corp., 120 S. LaSalle St., Chicago 3, Ill.

J. H. McMartin, field engineer, Louden Machinery Co., Fairfield, Iowa. (Mail) 303 E. Washington St.

M. Ray Parsons, Cpl., Corps of Military Police, USA. (Mail) Prov. MP Co., Sta. Comp., T-1575, Camp Lee, Va.

Thomas P. Ryan, field representative, plywood division, Pacific Mutual Door Co., 2141 S. Throop St., Chicago 8, Ill.

W. H. Sheldon, assistant professor of agricultural engineering, Michigan State College, East Lansing, Mich. (Mail) Box 78-B, RR No. 2.

Julian M. Snyder, vice-president and director of marketing and research, Erwin, Wasey and Co., Inc. (Mail) "Rock Ridge," Union Ave., Harrison, N. Y.

TRANSFER OF GRADE

W. H. Dickerson, Jr., assistant agricultural engineer, Virginia Polytechnic Institute, Blacksburg, Va. (Mail) Box 599 (Junior Member to Member)

Necrology

JOSEPH H. FULMER, president, Fulmer Alfalfa Drier Co., Nazareth, Pa., passed away on May 14.

A native of Pennsylvania, Mr. Fulmer was known to the members of the American Society of Agricultural Engineers for his experimental work in the dehydrating of forage crops which he started as early as 1912. In 1925 he built one of the first successful dehydrators for this purpose. His original dehydrator is still operating on the well-known Green Acre Farms, owned and operated by Mr. Fulmer, although many changes have been made in it from time to time.

Mr. Fulmer was noted in his community as an inventor and pioneer of various improvements in farm machinery including tractors, the two-row cultivator, motorized field crop sprayer, four-row corn planter, motorized weeder, and a two-row potato digger.

Mr. Fulmer was a member of several engineering and scientific organizations. He is survived by his wife and one brother and one sister.

Disappointed in "Plowman's Folly"

To the Editor:

I HAVE been interested in the discussion of "Plowman's Folly," but I want to say that I was much disappointed in Mr. Faulkner's book, and my opinion regarding it is shared by most of those with whom I have discussed it.

The only erosion control measure we are having any success with here is terracing. We are doing about 1,000 acres a year, and it is all from voluntary applications and from farmers who terrace each year until their entire farms are protected.

There is no government agency nor farm organization sponsoring the program. The farmers are paying the entire cost and the work is costing around $250 to $300 per mile. I have one customer in this county (Shelby) who has terraced 2100 acrès of a boundary of 3400 acres, and he intends to terrace the remainder at the rate of about 300 acres a year."

W. Forrest Smith

Engineering and construction service
Shelbyville, Kentucky

Why Agricultural Engineers?

BROADLY speaking, agricultural engineering involves the application of the principles of engineering, agriculture, and general sciences to the problems of agriculture. But why was it founded and why has it flourished as a distinct branch of the engineering profession? Briefly, the answer is twofold: (1) There were plenty of men well trained in civil, mechanical, and other branches of engineering but lacking adequate familiarity with the sensitive, complex science and business of agriculture, and (2) there were also plenty of men well trained in general agriculture and in some of its specialties, such as agronomy, horticulture, etc., but not in engineering. The electrical engineer may specialize in rural electrification and the architectural and civil engineer in farm structures; the agricultural engineer, however, is a specialist in these areas, both through education and daily experience.

Friends from Afar

(Continued from page 279)

As the world's largest and most firmly established organization within the profession, the American Society of Agricultural Engineers may well ponder what are its opportunities, indeed its moral obligations, to serve the profession and the peoples in other lands. Should we hold formally to national boundaries, giving informal aid and encouragement to the founding and growth of separate but similar societies, each in its own nation? Or should we outgrow the national concept embodied in the name and origin of our Society and let it assume the international or non-national nature of science?

Already our membership represents a dozen different foreign countries, down from a score due to war conditions. However, numbers are so few as to be only token representation except in the case of Canada. There the membership per million population is about one-third as great as in the United States. If based upon the volume of agricultural engineering activity, the fraction no doubt would be greater.

No other country has the same circumstances of geographical adjacency, identical language, and similarity in social and agricultural conditions. Difficulties of distance and of varying conditions can be and in lesser degree already are being met by creation of geographical sections. Language is more formidable a barrier, one which would seem to limit the practical scope of the Society to the English-speaking or at least English-reading areas.

At this time we do not offer or even imply any answers to the questions we have raised. Probably this is no time to hurry toward such answers. We do submit them to our members, both the many in the United States and the few in other lands, as worthy of their thoughtful consideration. We believe the criterion should be the effective interchange of technology without infringement on national feeling, and without semblance of seeking domination.

PROFESSIONAL DIRECTORY

New Literature

"AIDS TO TECHNICAL WRITING," by R. C. Jordan, assistant director, and M. J. Edwards, research assistant, engineering experiment station, University of Minnesota. Bulletin No. 21 of the U. of M. Engineering Experiment Station, Minneapolis, 117 pages, 50 cents per copy.

This bulletin contains all the essential information concerning the mechanics of preparing and publishing technical and scientific papers, bulletins, and magazine articles in a convenient and readily accessible form. It takes up the preparation of material for letterpress and non-letterpress publication and for magazine use; it discusses bibliography, footnote form, the use of numbers, the handling and arrangement of equations and tables, proofreading, abbreviations, and letter symbols. There are several helpful sections on the use and preparation of photographs, drawings, and charts. A complete list of standard graphical symbols used in technical drawings is given. The whole bulletin is well illustrated. All the details and usages given conform to standard practice and are obtained from reliable authorities. Much of the detailed material applies specifically to the field of mechanical engineering, but the basic information can be applied to a great variety of technical and scientific work. The publication of this diverse and scattered information in one pamphlet will indeed prove to be of great value in the field of technical writing.

"AGRICULTURAL HANDBOOK," July 1944 edition, The Tire and Rim Association, Inc., 2001 First-Central Tower, Akron 8, Ohio. Price: 50 cents per copy.

This handbook contains the standard and recommended practices for agricultural tractor and implement rubber tires adopted by the T.R.A.

"THE CHEMISTRY AND TECHNOLOGY OF FOOD AND FOOD PRODUCTS," prepared by a group of specialists under the editorship of M. B. Jacobs, senior chemist, department of health, City of New York. Cloth, 7x10 inches. Set of 2 volumes: Volume I, 952 pages, 79 illustrations and 218 tables, ready now; Volume II, about 950 pages with many illustrations and tables, ready in September. Price for set of two volumes, $19.00; individual volumes, $10.50 each. Interscience Publishers, Inc., 215 Fourth Ave., New York 3, N. Y.

Volume I constitutes the first part of an exhaustive treatment of the chemistry and technology of food and food products. The whole field is broken down into 48 chapters, of which 25 are published in the first volume. Forty-one collaborators have prepared a unified authoritative work by approaching the problem from the point of view that an expert in any selected subject is best qualified to write about it. Thus, to cover the various phases of the subject matter, food technologists, chemists, biochemists, bacteriologists, sanitary engineers, public health officers, food inspectors, and entomologists are represented among the contributors.

The two volumes are divided into a total of six parts. The first, on fundamentals, deals with the aspects of food chemistry common to all foods. The second part concerns the descriptive aspects of particular food groups, and includes some account of the history, statistics, definitions, standards, composition and chemistry of these food groups. In part three, unit operations and processes applicable to most foods will be described. Part four will deal with the maintenance of sanitary and quality control of foods and food products. In part five, the principal methods of preserving foods will be delineated. Part six will be concerned with production methods for the principal foods. Throughout the entire book, the role played by adequate nutrition in modern life is stressed.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any Notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

AGRICULTURAL ENGINEER wanted by a well-known national organization to engage in sales promotion work on farm buildings, preferably someone in his early thirties with good engineering training and farm background and with plenty of initiative and ingenuity. Special training in farm buildings would be helpful to person selected. Discharged service men will receive special consideration. Write giving full details as to education, experience, etc. PO-164

SALES ENGINEERS, preferably 32 to 38 years of age, with college education in engineering and with sales experience, are wanted by a large national manufacturing organization to engage in the sale of farm buildings through dealers. While a postwar project, qualified applicants will be interviewed now. Special consideration will be given discharged service men who have qualifications sought. Write giving full particulars as to education, experience, etc. PO-163

INSTRUCTOR in farm machinery and farm motors wanted by a state agricultural school of secondary vocational grade, for six months beginning October 1st. Write A. C. Heine, head, agricultural engineering dept., West Central School and Station, Morris, Minn.

DEVELOPMENT ENGINEERS AND DRAFTSMEN for agricultural equipment wanted for plant in Middle Atlantic Section. Factory in region almost devoid of equipment manufacturing but with excellent marketing possibilities for certain badly needed new products. Good salaries will be paid in proper proportion to experience and ability. In writing please give full account of education, experience, qualifications, draft and family status, and present salary. Include photograph if possible. PO-162

RURAL DEPARTMENT MANAGER wanted for permanent employment with an eastern electric utility. Immediate opening for competent college-trained, agricultural engineer with experience in modern business promotional sales methods. Familiarity with Pennsylvania-German farmer customs desirable. Write fully. PO-160

FARM EQUIPMENT ENGINEERS. National merchandising organization planning large farm equipment program has openings for senior and junior design engineers. Write experience, draft status, salary expected. Replies confidential. PO-155

ENGINEER interested in drainage research wanted. Southern state with large acreage needing drainage plans to begin intensive research program. First letter should give training, experience and references. PO-153

POSITIONS WANTED

AGRICULTURAL ENGINEER available. Six years' experience in rural electrification with private power company and government power project; experience in educational and research phases of the work. Two years' experience in farm management with state institution. Well acquainted with personnel of the land-grant colleges in midwest and southern states. Two years' experience as mechanical engineer and plant supervisor for large industrial concern. B. S. degree from a Midwest university. Age 32, health excellent, married. PW-363

AGRICULTURAL ENGINEER with a B. S. degree in agricultural engineering from an eastern college is available for employment. Experience in soil conservation, drainage, and use of explosives in land drainage and land clearing; farm reared with experience and knowledge of the operation, care, and adjustment of farm machinery and equipment, also wood-working equipment and farm building construction. Age 38, married, two children. Would like position in teaching, research, or extension work. PW-362

AGRICULTURAL ENGINEER with a B. S. degree in agricultural engineering from a midwest college and training course in management, operating and buying with mail-order firm. Two years' experience in farm building appraisal, inspection and fire prevention. Present position, purchasing and planning of aircraft parts. Age, 27 years; married with two children; draft status, 2B. Would like position in development and promotion of farm buildings and equipment or in purchasing or production work in a factory manufacturing agricultural equipment. PW-361